Technical Information Handbook

GEORGIA POWER
A SOUTHERN COMPANY

To learn more about Georgia Power rates, products and services, call your Georgia Power representative or call the Business Call Center at 1-888-655-5888.

Georgia Power would like to acknowledge the contributions of Carrier Complete Systems. CCS provided information on HVAC energy requirements and heat recovery technologies.

Table of Contents

Rates

Electric Rates

Electric rates for commercial and industrial customers can generally be categorized into three types:

- Ratcheted, demand-based rates
- Time of use rates
- Marginal rates, including Real Time Pricing (RTP)

They differ in critical ways when it comes to calculations.

Ratcheted Rates

How to Recognize:

Ratcheted rates will have language in the tariff(s) like:

- Hours use of demand
- Billing demand
- Tiered pricing structure (first block of kWh at one rate, second block at another rate, etc.)

How to Calculate Pricing for Racheted Rates:

1. Determine Billing Demand by applying ratchet rules of the tariff/rider
2. Determine Hours Use Demand (HUD); HUD = kWh/Billing Demand
3. Apply tariff prices according to blocks and any breaks within each block
4. Apply other applicable tariffs such as ECCR, FF, FCR, etc. and appropriate taxes

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Time of Use Rates

How to Recognize:

Time of use rates will have language in the tariff(s) like:

- On-Peak, Off-Peak, Shoulder kWh and kW
- Timed (or block) pricing structure
- NOTE: there are market-based time of use rates that are real-time. In Georgia Power, these are called real-time pricing. The prices are confidential and are provided to the customer the day before or hour before the price takes effect, depending on the contract. In these cases, you will have to contact the utility to get blended averages (see pricing calculation worksheet)

How to Calculate Pricing for Time of Use Rates:

1. Obtain (or estimate) the on-peak, off-peak and shoulder (if applicable) kWhs and kW
2. Determine if Economy Demand charges are applicable (summer months only)
3. Apply appropriate tariff prices
4. Apply other applicable tariffs such as EECR, FF, FCR, etc. and appropriate taxes

Marginal Rates

How to Recognize:

Marginal rates will have language in the tariff(s) like:

- Hourly Prices
- Customer Baseline Load (CBL)
- Interval Data
- Incremental kWhs
- Demonstration

How to Calculate Marginal Rates:

RTP Bills will have both a standard or CBL bill and an RTP (incremental energy) bill

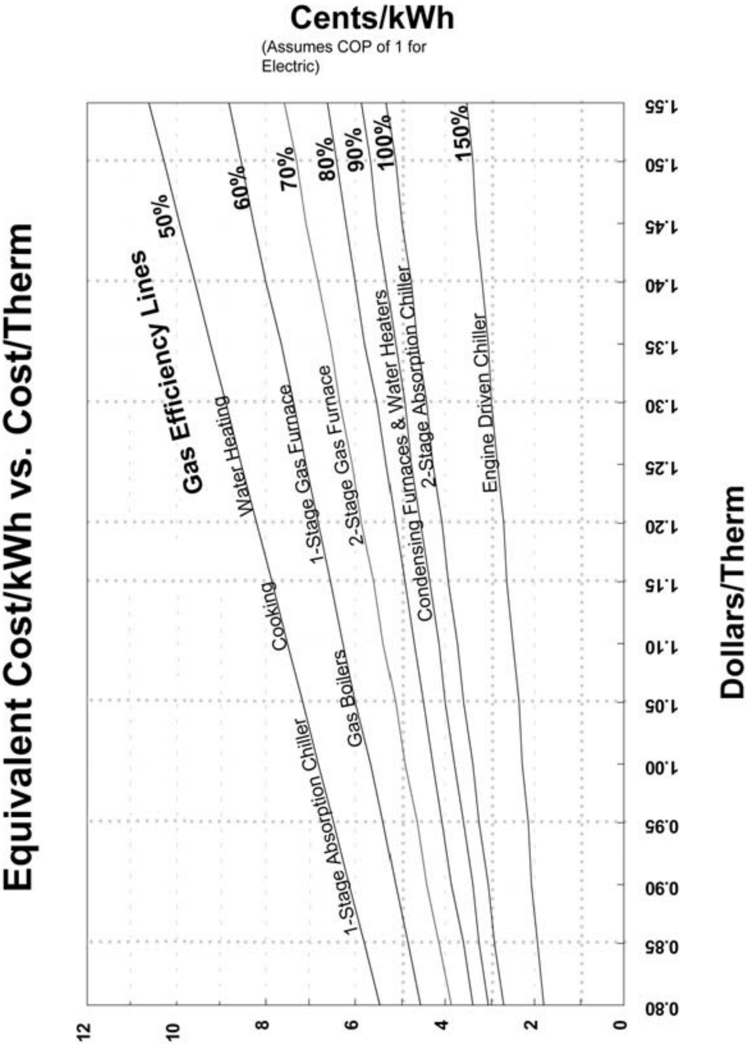
1. To calculate the standard or CBL bill, use the appropriate ratcheted or TOU steps as outlined previously
2. The RTP bill is calculated by multiplying the hourly kWh consumption by the hourly RTP price; repeat step for all hours of the month. (It is not as simple as multiplying the total kWhs by the average RTP price due to varying consumption amounts/weighting)
3. Apply other applicable tariffs such as ECCR, FF, FCR, etc. and appropriate taxes

Customer Choice in Georgia

Under the Territorial Act of 1973, many customers over 900 kW who are outside of municipal limits may choose their electric supplier. This is a one-time, irrevocable choice.

Customer Choice Considerations

Price Stability	Since your choice is for the life of the building, it is critical to evaluate your long-term costs. Beware of short-term fixed prices that escalate sharply after the first few years. Georgia Power's rates are regulated by the Public Service Commission. Municipal authority and cooperative rates are not.
Service Reliability	The cost of one outage can far outweigh any apparent price savings, depending on the customer. When evaluating overall price, outage costs should be included.
Generation Capability	Does the supplier have bricks and mortar generation? Or is it buying power on the open market? A supplier with a large percentage of bricks and mortar generation is better able to meet its customers' electricity needs cost-effectively over the long term than a supplier who must buy on the open market.
Ancillary Services	What other knowledge/assistance will the customer need? Georgia Power offers a host of technical and other energy services to its customers.



* Please refer to Page 91 for graph notations.

Conversions between Fuel Types

Gas:

1 Therm = 100,000 Btu = 100 CCF

1 cubic foot = 1,000 Btu

1 MCF = 1,000,000 Btu = 10 therms

Electricity:

1 kWh = 3,413 Btu

Liquid Gas (Propane):

1 cubic foot = 2,500 Btu

1 pound = 21,500 Btu

1 gallon = 91,160 Btu

Oil:

1 gallon = 140,000 Btu

Coal:

1 ton = 25 Million Btu

1 pound = 12,500 Btu

HVAC

Recommended Systems by Building Type

Building Type	System #1	System #2
Hospitals	Chillers, VAV, room control. Energy recovery ventilators on operating rooms. Heat pump water heater in kitchen/laundry.	—
Schools	Water source heat pump with cooling tower and boiler; split system for offices; package unit for auditorium. Heat pump water heater in kitchen. Small electric water heater in teachers' lounge.	Through-the-wall units in classroom.
Restaurants	Rooftop package heat pumps. Heat pump water heater in kitchen.	Split system heat pump. Heat pump water in heater kitchen.
Small Offices/Retail	Split system heat pump. Point of use water heater.	Small-tank water heater.
Hotels (small)	Through-the-wall heat pump.	Heat pump water heater in laundry, ducting cooling to lobby.

Recommended Systems by Building Type *(cont.)*

Building Type	System #1	System #2
Hotels (large)	Water source heat pumps with cooling tower and boiler. Heat pump water heater in kitchen and indoor pool.	Two-pipe system with fan-coil units, chillers, electric resistance heat.
Motels	Through-the-wall heat pumps. Gas water heater with recirculating pump.	—
Churches	Weekend only: Electric heat.	Weekday/school buildings: Package unit heat pumps.
Historic Buildings	Ground source heat pumps.	—

Cost Comparisons for System Types:

A quick and easy way to estimate costs for different systems, EFLH analysis is not as accurate as building modeling. This analysis generally gives reasonable estimates for operating costs however.

Annual cost = EFLH *City Factor * kW * $/kWh + 12 * kWd * $/kW
Annual cost = EFLH * Btuh * $/therm /100000

Where:
EFLH = taken from table (on following page)
City Factor = Degree-day factoring to adjust EFLH
kW = Connected kW of equipment
kWd = Diversified kW (takes cycling into account, see miscellaneous section for table)
Btuh = Rated Btu input of equipment

Typical EFLH for Buildings, Atlanta

Type Business	EFLH, Air Conditioning	EFLH, Heating
Small Retail 0-25 M ft^2	2000	800
Medium Retail	2200	700
Large Retail	2400	500
Small Office	1500	800
Medium Office	1800	800
Large Office	2000	800
Convenience Stores	2500	800
Supermarkets	2500	500
Hotels/Motels	1600	800
Fast Food	3000	1500
Restaurants	1800	800
9 Month Schools	1000	800
12 Month Schools	2000	800
Healthcare (drs.' offices, etc.)	2000	800
Churches	600	400
Services	1500	800
Warehouses	1500	800

City Factors

City	Cooling Factor	Heating Factor
Alma	1.37	.61
Brunswick	1.48	.53
Macon	1.33	.75
Rome	.96	1.03

To find your city factor:
City factor, cooling = Cooling degree days for the city/1670
City factor, heating = Heating degree days for the city/3021

Typical Heating and Cooling Requirements

Type of Bldg.	Btuh/SF, Cooling	SF/ton, Cooling	Btu/SF, Heating	Supply CFM/SF
Apartments	24	500	21	0.8
Audit. & Theater	40	300/19*	38	1.3
Banks	49	245	48	1.6
Barber Shops	46	260	44	1.5
Bars & Taverns	120	100/10*	114	4.0
Beauty Parlors	63	190	60	2.1
Bowling Alleys	38	315	37	1.3
Churches	35	340/21*	33	1.2
Cocktail Lounges	65	185	63	1.6
Comp. Rooms	141	85	20	4.7
Dental Offices	50	240	49	1.7
Dept. Stores – Basement	33	360	32	1.1
Dept. Stores – Main Floor	39	310	38	1.3
Dept. Stores – Upper Floors	29	410	28	1.0
Dormitory, Rooms	38	320	35	1.3
Dormitory, Corridors	20	600	18	0.7
Dress Shops	40	300	39	1.3
Drug Stores	77	155	75	2.6
Factories	39	310	38	1.3
High Rise Office – Ext. Rooms	43	280	41	1.4
High Rise Office – Int. Rooms	35	340	33	1.2
Hospitals	69	175	67	2.3
Hotel, Guest rooms	35	345	35	1.2
Hotel, Corridors	28	425	27	0.9

Typical Heating and Cooling Requirements (cont.)

HVAC

Type of Bldg.	Btuh/SF Cooling	SF/ton Cooling	Btu/SF Heating	Supply CFM/SF
Hotel, Public Spaces	51	235	48	1.7
Industrial Plants, Offices	35	345	34	1.2
General Offices	33	360	32	1.1
Plant Areas	38	315	37	1.3
Libraries	43	280	40	1.4
Low Rise Office, Ext. Rooms	39	310	32	1.3
Low Rise Office, Int. Rooms	33	365	32	1.1
Medical Centers	35	340	33	1.2
Motels	29	420	27	1.0
Office (small suite)	40	300	38	1.3
Post Office, Ind. Office	40	300	39	1.3
Post Office, Central Area	43	280	41	1.4
Residences	20	600	20	0.7
Restaurants	60	200	60	2.0
Schools & Colleges	42	285	40	1.4
Shoe Stores	53	225	52	1.8
Shopping Centers, Supermarkets	30	400	28	1.0
Retail Stores	32	370	31	1.1
Specialty Stores	57	210	57	1.9
Schools, Elem.	36	335	32	1.2
Schools, Middle	36	335	32	1.2
Schools, High	33	365	32	1.1
Schools, Vo-Tech	22	550	20	0.8

* People/Ton

12,000 Btu = 1 ton of air conditioning

Heat Gain from Typical Electric Motors†

Motor Name-plate or Rated Horse-power	Motor Type	Nominal rpm	Full Load Motor Efficiency in Percent	Motor In, Driven Equip-ment in Space Btuh	Motor Out, Driven Equip-ment in Space Btuh	Motor and Driven Equip-ment Out of Space Btuh
0.25	Split Ph.	1750	54	1,180	640	540
0.33	Split Ph.	1750	56	1,500	840	660
0.50	Split Ph.	1750	60	2,120	1,270	850
0.75	3-Ph.	1750	72	2,650	1,900	740
1	3-Ph.	1750	75	3,390	2,550	850
1	3-Ph.	1750	77	4,960	3,820	1,140
2	3-Ph.	1750	79	6,440	5,090	1,350
3	3-Ph.	1750	81	9,430	7,640	1,790
5	3-Ph.	1750	82	15,500	12,700	2,790
7,5	3-Ph.	1750	84	22,700	19,100	3,640
10	3-Ph.	1750	85	29,900	24,500	4,490
15	3-Ph.	1750	86	44,400	38,200	6,210
20	3-Ph.	1750	87	58,500	50,900	7,610
25	3-Ph.	1750	88	72,300	63,600	8,680
30	3-Ph.	1750	89	85,700	76,300	9,440
40	3-Ph.	1750	89	114,000	102,000	12,600
50	3-Ph.	1750	89	143,000	127,000	15,700
60	3-Ph.	1750	89	172,000	153,000	18,900
75	3-Ph.	1750	90	212,000	191,000	21,200
100	3-Ph.	1750	90	283,000	255,000	28,300
125	3-Ph.	1750	90	353,000	318,000	35,300
150	3-Ph.	1750	91	420,000	382,000	37,800
200	3-Ph.	1750	91	569,000	509,000	50,300
250	3-Ph.	1750	91	699,000	636,000	62,900

HVAC

Typical Equipment Energy Requirements

System Type	kW/ton, Cooling	Heating System Efficiency (electric)	Heating System Efficiency (gas)
Rooftop package unit	0.9-1.3	0.95	0.75-0.77
Water-source heat pump with cooling tower and boiler	0.86-1.1	2.0	1.8-1.9
4-pipe system, chilled water, boiler, air handlers	0.8-1.3	0.8	0.6-0.7
2-pipe system, chilled water, boiler, air handlers	0.75-1.1	0.82	0.6-0.7
Split-system, residential	1.0-1.2	0.95	0.7-0.92
Split-system, commercial	0.7-1.3	0.95	0.75-0.77
Heat pump, split-system	1.0-1.2	2.3	N/A
Heat pump, package	0.9-1.3	2.3	N/A
Ground water source heat pump	0.38-0.5	2.8	N/A

Note: the heating efficiency considers heat exchanger losses, fan requirements, pump power, and other losses.

EER Rating to kW Conversions

EER Rating	kW, Cooling
6.0	2.0
6.5	1.85
7.0	1.71
7.5	1.60
8.0	1.50
8.5	1.41
9.0	1.33

EER Rating	kW, Cooling
9.5	1.26
10.0	1.20
10.5	1.15
11.0	1.09
12.0	1.0
13.0	0.92
14.0	0.86

ASHRAE Psychrometric Chart No. 1

Normal Temperature

Barometric Pressure: 29,921 Inches of Summary
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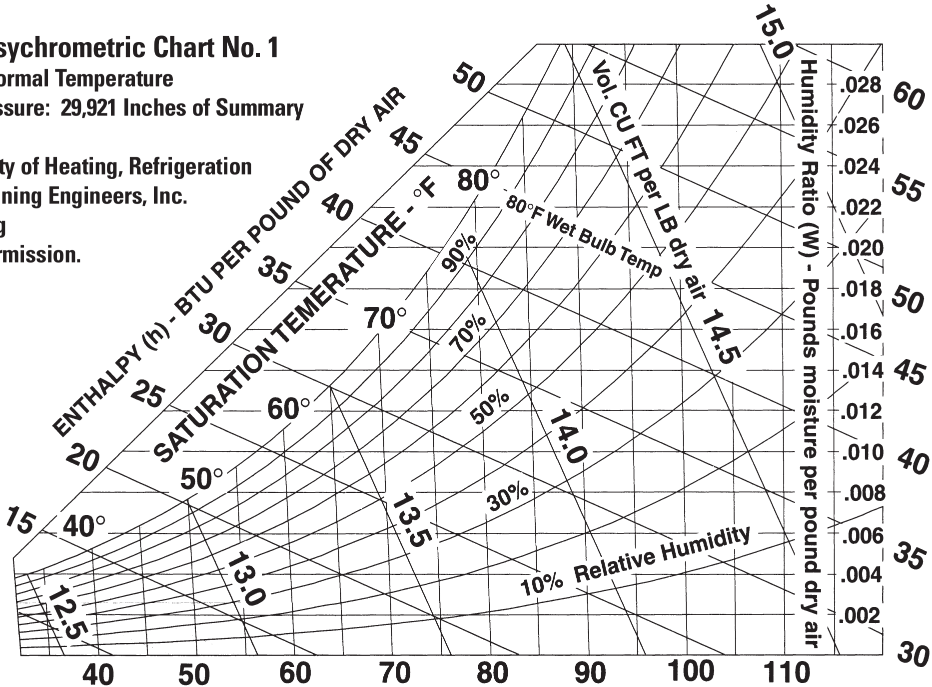


Reduced from ASHRAE Psychrometric Chart No. 1

HVAC

Heat Recovery Opportunities

Heat Wheel

This system involves a motor-driven wheel packed with heat absorbing material, installed directly in the ventilation air system, with outdoor and exhaust air kept separate. This system transfers heat from a warmer stream to a cooler one and some systems can serve both in the heating and air conditioning mode.

Runaround System

When the outdoor air intake and exhaust air duct are not in close proximity, heat transfer can be accomplished by circulating an ethylene glycol solution. One finned tube heat exchanger is located in the outdoor air stream, one in the exhaust air stream, with the two being connected by a pipe loop. A pump circulates the liquid for heat transfer.

Air-to-Air Heat Exchanger

In contrast to the aforementioned techniques, the air-to-air heat exchanger has no moving parts but conveys heat between exhaust and outdoor air streams by means of a counterflow technique. The heat exchanger is an open-ended steel box compartmented into many narrow passages. Energy is transferred by conduction through the walls of the passages so that contamination of the makeup air cannot occur.

Heat Pipe

A heat pipe is a sealed, static tube in which a refrigerant transfers heat from one end of the device to the opposite end. The device is installed through adjacent walls of inlet and exhaust ducts with their opposite ends projecting into each air stream. A temperature difference between the ends of the pipe causes the refrigerant to migrate by capillary action to the warmer end where it evaporates and absorbs heat. It then returns to the cooler end, condenses, and gives up the heat.

Economizer

Reducing the amount of air conditioning needed by utilizing the cooling potential of outdoor air can be accomplished by the use of "economizer" systems. A mixed air temperature controller regulates the proportion of outside air admitted, opening the outdoor air dampers as the mixed air temperature increases. The most effective systems, called enthalpy controllers, take into account the humidity control of the air as well as the dry bulb temperature.

Peak Demand Controller

This device is programmed to cycle electricity consumption by limiting total demand during on-peak hours. This technique is popular in conjunction with closed loop water source heat pump systems and is used to achieve higher savings with a minimum of interruption.

Off-Peak Thermal Storage

Throughout a 24-hour period, the demand for electric power, in most service areas, fluctuates widely. Typically, it is lowest at night. Often it is advantageous, not just for the utility but for the customer, to shift some electrical usage from on-peak to off-peak operations, as utility rates are based on the cost to serve the customer. Heating and cooling loads can be shifted through thermal storage. Heat captured from internal sources can be saved and/or heat generated at night can be stored for later use. With cooling there is little energy savings, but demand load can be shifted and demand charges reduced. By running chillers at night and storing cool water or ice, the size of chillers can be reduced. Closed water source heat pump systems lend themselves to achieve savings through thermal storage and captured heat for use during off-peak hours.

Building Envelope

Sustainable Building Design

There's more of a focus now on "sustainable buildings." This term is used for buildings that have considerably lower impact on the environment during both construction and long-term operation than a typical building of similar size and location. It's very important to take local conditions (economic and environmental) into account when designing a low-impact building.

There aren't rules of thumb available yet. The most active groups in this movement recommend modeling the building to assess the energy-using features.

Basic R-value information and calculations

Total heat flow = U * TD * Area

Where:
U = 1/R
TD = Design temperature difference
Area = Total area of space with that R value

To estimate total R value of a series of material, add the values of each together.

To Compare Annual Cost:
Use EFLH Calculation (described above) as follows:

Annual cost = Tons/1000 SF * Area (SF)/1000 * Equipment kW/ton * EFLH * $/kWh + Tons/1000 SF * Area (SF)/1000 * Equipment kW/ton * 12 * $/kW

Heating is analogous. If comparing with gas, remember to use efficiency. See following page for Tons/1000 SF and Equipment kW/ton.

Ceiling Insulation

Roof Type	Insulation	U Factor	TD (Cool)	Btu/hr/ 1000 SF	Tons/ 1000 SF	TD (Heat)	Btu/hr/ 1000 SF	kW/ 1000 SF
Flat Steel	No	.64	80	51200	4.26	48	30720	9.0
Deck, No Ceiling	1” insulation (R-3 or R-4/ inch)	.23	80	18400	1.53	48	11040	3.23
	3” insulation (R-3 or R-4/ inch)	.10	80	8000	0.67	48	4800	1.41
Frame Roofing, Attic, Ceiling	No insulation	.15	55	8250	0.69	48	7200	2.11
	R-11 insulation	.07	55	3850	0.32	48	3360	0.98
	R-19 insulation	.04	55	2200	0.18	48	1920	0.56

Wall Insulation

Wall Type	Insulation	U Factor	TD (Cool)	Btu/hr/ 1000 SF	Tons/ 1000 SF	TD (Heat)	Btu/hr/ 1000 SF	kW/ 1000 SF
4” Face Brick–Cavity–8” Concrete Block	No insulation	.30	22	6600	0.55	48	14400	4.22
	1” insulation (R-5/inch in Cavity)	.11	22	2420	0.20	48	5280	1.55
	2” insulation (R-5/inch in Cavity)	.07	22	1540	0.128	48	3360	0.98

Building Envelope

Glass (transmission losses/gains only–does not include radiation!)

Glass Type	U Factor	TD (Cool)	Btu/hr/ 1000 SF	Tons/ 1000 SF	TD (Heat)	Btu/hr/ 1000 SF	kW/ 1000 SF
Single	1.06	14	1484	0.124	48	5424	1.589
Double, 1/4" air space	0.61	14	854	.071	48	3120	0.914
Prime + Storm Window	0.54	14	756	.063	48	2688	0.788

Slab Floor

Insulation	U Factor	TD (Cool)	Btu/hr/ 100 LF	Tons/ 100 LF	TD (Heat)	Btu/hr/ 1000 LF	kW/ 100 LF
No Insulation	0.81	–	–	–	48	3888	1.14
1" Insulation (R-5 /inch)	0.41	–	–	–	48	2968	0.58
2" Insulation (R-5 /inch)	0.21	–	–	–	48	1008	0.30

Insulating Values for Common Building Materials

Materials	R Value	U Value*
Air Space, 3/4"	0.91	1.098
Batt or Blanket Insulation—1"	3.7	0.27
Batt or Blanket Insulation—2"	7.4	0.135
Batt or Blanket Insulation—3 5/8"	13.4	0.075
Batt or Blanket Insulation—6"	19.0	0.053
Batt or Blanket Insulation—6 1/2"	22.0	0.045
Brick, common—4"	0.44	2.27
Beadboard Plastic	4.0	0.25
Built-up Roofing	3.0	0.333

Insulating Values for Common Building Materials (cont.)

Materials	R Value	U Value*
Cellulose Fiber Blown In—3 1/2"	13.0	0.077
Concrete, Block—8"	1.11	0.900
Concrete, Block (Cores filled with vermiculite)—8"	1.94	0.515
Concrete, Poured—10"	1.0	1.0
Expanded Polyurethane—1"	6.25	0.16
Expanded Polyurethane—2"	12.5	0.08
Extruded Styrofoam—1"	5.4	0.185
Flexicore—4", 8", 10"	0.89	1.124
Glass Block	2.38	0.42
Gypsum Board—1/2"	0.45	2.222
Insulation Board—1/2"	1.52	0.657
Plaster with metal lath—3/4"	0.23	4.347
Plywood—3/8"	0.47	2.127
Roof Deck—1"	2.78	0.36
Sheathing and flooring—3/4"	0.92	1.086
Shingles, asbestos	0.21	4.76
Shingles, wood	0.78	1.282
Siding, drop—3/4"	1.28	0.781
Steel Doors: 1 3/4" mineral fiber core	1.7	0.59
1 3/4" urethane foam core with thermal break	5.26	0.19
1 3/4" polystyrene core with thermal break	2.13	0.47
Siding, lap	0.78	1.282
Surface, inside (air film)	0.68	1.47
Surface, outside (15 mile per hour wind)	0.17	5.882
Windows: Single glass, outdoor exposure	0.88	1.136
Double glass, 1/4" apart	1.54	0.649
Double glass, 1/2" apart	1.72	0.581
Triple glass, 1/4" apart	2.13	0.469
Wood: Hardwoods (Maple, Oak, etc.)—1"	0.91	1.099
Softwoods (Pine, Fir, Cedar, etc.)—1"	1.25	0.8
Wood Doors—1 1/2"	2.04	0.49
Wood Doors—1 1/2" w/Storms	3.7	0.27

$*U = \frac{1}{R}$

U x Temperature Difference = heat loss in watts per square foot.

Basic Passive Solar Techniques

Technique	What it Does
Overhang on South-facing windows	Reduces summer cooling load while letting in natural light; reduces glare. In winter, allows solar gain.
Heavy ceramic tile or stone floors in lobbies with large expanse of glass	Absorbs heat during the day and releases at night. This reduces peak cooling load and helps maintain wintertime temperatures.
Water tubes in areas with large glass expanse	Absorbs heat during the day, and can be connected to potable water to reduce water heating costs.
Water boxes on roof	Absorbs heat during the day to preheat potable water.
Reflective roof coatings	Reduces heat absorption, lowering cooling requirements.
Low-emissivity glass	Reduces glare and cooling load.
Natural light/light tubes	Reduces lighting energy requirement; can improve employee performance.

Water Heating

Water Heating Systems

System Type	Application	Considerations
Tank-Style	Typical potable water requirements: small office areas, retail, etc.	Easy to use, install, maintain. Familiar to most customers.
Boiler	Large process water heat requirements (laundries, kitchens, space heat).	Relatively easy to use, install, maintain. Electric will lose elements if water quality not monitored properly. Gas will lose efficiency and have long-term maintenance issues if water quality not monitored.
Point-of-Use	Small medical offices, remote washrooms.	Removes need for circulating pump. Can reduce overall plumbing costs (only need one piping run instead of two).
Thermal Storage	Hospitals, industrial sites, schools.	Heats water during off-peak in sealed storage tank. Potable water is run through heat exchanger to tap heat in tank as needed. Can take a lot of room (although they can be placed outside).
Heat Pump Water Heater	Laundries, kitchens, pools.	Provides dehumidification as well. Must be sized to meet either cooling or water heating load.

Water Heating Calculations

Recovery

$$\frac{4.1 \times \text{Wattage}}{1{,}000} = \text{GPH at } 100° \text{ Rise}$$

1 kWh will raise the temperature of 4.1 gallons of water 100°F at 100% efficiency in one hour.

Figuring Load Required to Heat Water

$$\text{kW} = \frac{\text{Gallons} \times 8.34 \ \{\text{Wt. of Gal. of Water}\} \times \text{Degrees F. Rise}}{3{,}413 \ \{\text{Btu Content}\} \times \text{Time in Hours} \times \text{Efficiency} \ \{0.98\text{-}1.0\}}$$

Estimating Water Heating Electrical Energy Use

$$\text{kWh} = \frac{\text{Gallons Per Time Period} \times 8.34 \times \text{Average Degree F. Rise}}{3{,}413 \times \text{Efficiency} \ \{0.98\text{-}1.0\}}$$

Booster Heater Sizing (Rule of Thumb)

G.P.H. {Gals. Per Hr.} ÷ 10 = kW Required {40°F Temp. Rise}
Rinse Water Temperature 180°-Standard Set by U.S. Department of Health

PER MEAL kWh ESTIMATES-WATER HEATING FOR RESTAURANTS

	Total Use	*Dishwasher Booster****
Full Meal Restaurants and Cafeterias	0.6 kWh	0.2 kWh
Drive-in Snack Shops	0.2 kWh	0.04 kWh

***Booster Use is Included in Total Use Figures

Water Heating

Water Use Charts

Type of Building	Maximum Hourly	Maximum Daily	Average Daily
Men's Dormitories	3.8 gal/student	22.0 gal/student	13.1 gal/student
Women's Dormitories	5.0 gal/student	26.5 gal/student	12.3 gal/student
Motels: No. of Units			
20 or less	6.0 gal/unit	35.0 gal/unit	20.0 gal/unit
60	5.0 gal/unit	25.0 gal/unit	14.0 gal/unit
100 or more	4.0 gal/unit	15.0 gal/unit	10.0 gal/unit
Nursing Homes	4.5 gal/bed	30.0 gal/bed	18.4 gal/bed
Office Buildings	0.4 gal/person	2.0 gal/person	1.0 gal/person
Food Service Establishments Type A-Full Meal Restaurants & Cafeterias	1.5 gal/maximum meals/hours	11.0 gal/maximum meals/hour	2.4 gal/average* meals/day
Type B-Drive-ins, Grilles, Luncheonettes, Sandwich & Snack Shops	0.7 gal/maximum meals/hour	6.0 gal/maximum meals/hour	0.7 gal/average* meals/day
Apartment Houses: No. of Apartments			
20 or less	12.0 gal/apt.	80.0 gal/apt.	42.0 gal/apt.
50	10.0 gal/apt.	73.0 gal/apt.	40.0 gal/apt.
75	8.5 gal/apt.	66.0 gal/apt.	38.0 gal/apt.
100	7.0 gal/apt.	60.0 gal/apt.	37.0 gal/apt.
200 or more	5.0 gal/apt.	50.0 gal/apt.	35.0 gal/apt.
Elementary Schools	0.6 gal/student	1.5 gal/student	0.6 gal/student*
Junior & Senior High Schools	1.0 gal/student	3.6 gal/student	1.8 gal/student

*per day of operation

The hourly and daily hot water demands listed represent the maximum flows metered in each type of building.

Food Service Hot Water Consumption

Use	Gallons Per Hour
Vegetable Sink	15
Single Compartment Sink	20
Double Compartment Sink	40
Triple Compartment Sink	60
Pre-Rinse for Dishes-Shower Head Type (Hand Operated)	45
Pre-Scraper for Dishes (Salvajor Type)	180
Pre-Scraper for Dishes (Conveyor Type)	250
Bar Sink (Three Compartment)	20
Bar Sink (Four Compartment)	25
Chemical Sanitizing Glasswasher	60
Lavatory	5
Service Sink	10
Cook Sink	10
9-12 Pound Washers	45
16 Pound Washers	60
Shower	20

Required Water Temperatures*

Dishmachine Final Rinse (At Manifold)	180°
Chemical Sanitizing Dishwasher	140°
General Purpose	140°
Bar Sinks	125°
Lavatories	125°
Chemical Sanitizing Glasswasher	75°

*From "Guideline for Hot Water Generating Systems for Food Service Establishments." Michigan Department of Public Health.

NSF—Dishwasher Rinse Water Requirements

	180° Rinse Water Demands (Pressure at Washer—20 psi)
1. 16" x 16" Single Tank, Stationary Rack	69 Gals/Hr.
2. 18" x 18" Single Tank, Stationary Rack	87 Gals/Hr.
3. 20" x 20" Single Tank, Stationary Rack	104 Gals/Hr.
4. Multiple Tank, Conveyor, Flat	347 Gals/Hr.
5. Multiple Tank, Conveyor, Inclined	277 Gals/Hr.
6. Single Tank, Conveyor	416 Gals/Hr.

System Wattages for Typical Lamp/Ballast Combinations

Ballast Type (No.) No. of Lamps	Lamp Type									
	40 Watt T12	34 Watt T12	32 Watt T6	F96/75W/SL	F96/60W/SL	F96/59W/T8	F96/110W/HO	F96/215W/VHO	F96/215W/VHO	F96/185W/VHO
Standard (1) 1-Lamp	49	41	N/A	98	83	N/A	135	125	230	200
Energy Eff. (1) 1-Lamp	52	44	37	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Electronic (1) 1-Lamp	35	28	34	86	N/A	N/A	N/A	N/A	N/A	N/A
Electronic (1)* 1-Lamp	N/A	N/A	32	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Standard (1) 2-Lamp	96	79	N/A	175	138	N/A	257	219	440	375
Energy Eff. (1) 2-Lamp	86	70	70	158	123	N/A	237	199	N/A	N/A
Electronic (1) 2-Lamp	69	57	62	134	105	118	194	160	N/A	N/A
Electronic (1)* 2-Lamp	N/A	N/A	51	N/A	N/A	102	N/A	N/A	N/A	N/A
Standard (2) 3-Lamp	148	127	N/A							
Energy Eff. (2) 3-Lamp	134	109	107							
Electronic (1) 3-Lamp	108	90	88							
Electronic (1)* 3-Lamp	N/A	N/A	75							
Standard (2) 4-Lamp	192	158	N/A							
Energy Eff. (2) 4-Lamp	172	140	140							
Electronic (1) 4-Lamp	142	114	108							
Electronic (1)* 4-Lamp	N/A	N/A	95							

All wattages are +/- 4 Watts. The actual wattages depend on the specific manufacturer's lamp and ballast combinations.

Lumen output also varies with lamp/ballast combinations.

Actual light output is dependent on the ballast factor.

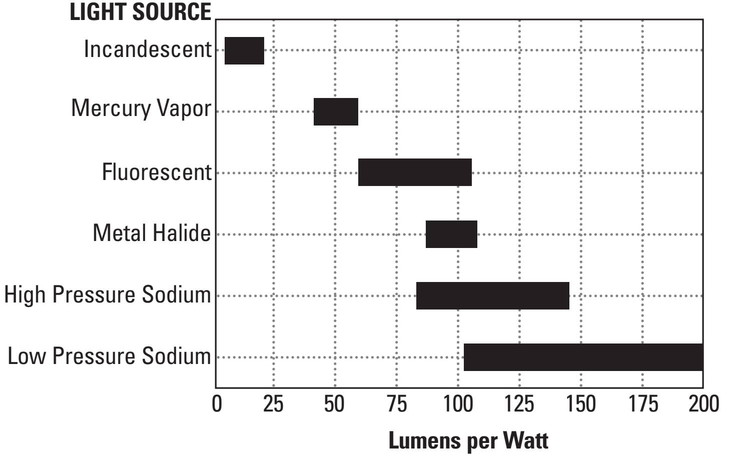
*These ballasts are low power ballasts. In addition to consuming less energy, they will result in reduced light output.

Lighting

Light Level Recommendations

The Illuminating Engineers' Society of North America (IESNA) has recently changed its focus on lighting levels. They have made a dramatic shift from considering the lighting quantity only to consider the quality of lighting. For full details, consult chapter 10 of their manual (available at www.iesna.org).

Efficacy Comparison Chart



Reflectance Values of Different Surfaces

Material Category	Description	Reflectance (%)
Glass	Clear or Tinted	5-10
	Reflective	20-30
Masonry	Brick, Red	10-20
	Cement, Gray	20-30
	Granite	20-25
	Limestone	35-60
	Marble, Polished	30-70
	Plaster, White	90-92
	Sandstone	20-40
Metals	Aluminum, Brushed	55-58
	Aluminum, Etched	70-85
	Aluminum, Polished	60-70
	Stainless Steel	50-60
	Tin	67-72
Paint	White	70-90
Wood	Light Birch	35-50
	Mahogany	6-12
	Oak, Dark	10-15
	Oak, Light	25-35
	Walnut	5-10

The Effect of Lighting on Cooling Load

Source	Initial Lumens/ Watt	Lamp Hours Life	System kW per 1,000,000 Lumens	Btu Input*	Ton-hours Cooling Required*
Incandescent GE 100A A-19/F	17.5	750	57.1	194882	16.24
Quartz GE Q1000T3/CL	21.5	2,000	46.51	158749	13.23
Fluorescent Standard Ballast F40CW	71.6	20,000	13.9	47680	3.97
Fluorescent Standard Ballast F40LW/RS/WMII	76.5	20,000	13.08	44642	3.72
Fluorescent Max Miser I Ballast f40CWIRS/WMII	85.4	20,000	11.71	39966	3.33
Fluorescent Optimiser System FM28KW	87.9	15,000+	11.37	38806	3.23
Mercury-Regulator (CW) Ballast HR400DX33	48.9	24,000	20.44	69762	5.81
Metal Halide Auto Regulator (Peak Lead) Ballast MVR400/VBV	86.0	20,000	11.625	39676	3.31
High Pressure Sodium	102.9	20,000	9.72	33174	2.76

*Assumes 2500 Hours Use of the Lighting System Annually, 1,000,000 Lumen Output

Annual Cost for Lighting Systems

Annual cost = demand charge + energy charge, where
Demand charge = (Number of fixtures* W/fixture * $/kW * 12)/(1000)
Energy charge = (Number of fixtures * W/fixture*Annual burn hours * $/kWh)/1000

Outdoor Lighting

For Improved
—Safety
—Security
—Appearance
—Merchandising

Rule of Thumb Guides

1. Use efficient light sources (high pressure sodium, metal halide high intensity discharge lamps) that will produce maximum light output for the lowest use of energy and cost. Specify high power factor ballasts (minimum .90 P.F.)
2. "Positive Cutoff" fixtures on poles or buildings are preferred to reduce distracting glare for more attractive surveillance of premises.
3. Spacing to mounting height ratios between poles are preferred at a 3 to 1 ratio and not greater than a 4 to 1 ratio.
4. High reflectance materials and/or light paint for all possible vertical and horizontal surfaces will lighten dark areas, walkways, aisles, entrances, exits. Higher reflectances will help to quickly identify possible intruders.
5. Improve parking lot visibility and identification by applying two-foot white or yellow paint (thermal plastic) parking guidelines between cars. This technique will improve reflected light between cars on asphalt surfaces.

6. Perimeter lighting (75 feet or more when possible in front of buildings) will act as a light barrier deterrent to would-be intruders.
7. Floodlighting should not be directed out from a building more than twice the mounting height of the equipment above the ground. This avoids the problem of extreme light and dark areas in addition to the distracting glare problem.
8. Recommend installation of photocell and/or time switch controlled for maximum customer benefit.

Outdoor Lighting Levels

Building Exteriors	Minimum Footcandles
Entrances	
Active (pedestrian and/or conveyance)	5
Inactive (normally locked, infrequently used)	1
Building Floodlighting	
Bright surroundings	15
Dark surroundings	5
Building Surroundings	1
Parking Areas	
Self-Parking Area	1
Attendant Parking Area	2
Vital Locations or Structures	5

Lamp Table

Light Source	Burning Position	(a) Lamp Life	(b) Initial Lumens	Lamp & Ballast Wattage	Efficacy	(c) LLD	x	(d) LDD	=	(e) LLF
High Pressure Sodium Lamps (Clear)										
1000W	Any	24,000	140,000	1,100	127	.83	x	.65	=	.54
400W	Any	24,000	50,000	465	108	.83	x	.70	=	.58
310W	Any	24,000	37,000	380	97	.82	x	.70	=	.57
250W	Any	24,000	30,000	305	98	.83	x	.70	=	.58
200W	Any	24,000	22,000	250	88	.82	x	.70	=	.57
150W	Any	24,000	16,000	200	80	.83	x	.70	=	.58
100W	Any	24,000	9,500	135	70	.83	x	.70	=	.58
70W	Any	24,000	6,300	95	66	.83	x	.70	=	.58
50W	Any	24,000	4,000	63	64	.83	x	.70	=	.58
35W	Any	24,000	2,250	45	50	.83	x	.70	=	.58
Metal Halide Lamps (Clear)										
1500W	Vert.	3,000	155,000	1,625	95	.84	x	.65	=	.55
1000W(l)	Vert. (j)	12,000	115,000	1,050	110	.73	x	.65	=	.48
1000W	Vert.	12,000	110,000	1,050	105	.73	x	.65	=	.48
400W(l)	Vert. (j)	20,000	40,000	460	87	.68	x	.70	=	.48
400W	Vert.	20,000 (f)	36,000	460	78	.68	x	.70	=	.48
250W	Vert.	10,000	19,500	300	65	.76	x	.70	=	.53
250W(l)	Horz. (k)	10,000	23,000	300	77	.76	x	.70	=	.53
175W	Vert.	10,000 (g)	14,000	210	67	.67	x	.70	=	.47
175W(l)	Horz. (k)	6,000	12,000	210	71	.67	x	.70	=	.47

Lamp Table (cont.)

Light Source	Burning Position	(a) Lamp Life	(b) Initial Lumens	Lamp & Ballast Wattage	Efficacy	(c) LLD	x	(d) LDD	=	(e) LLF
Mercury Lamps (Deluxe White)										
1000W	Vert.	24,000 +	63,000	1,060	59	.50	x	.65	=	.32
400W	Vert.	24,000 +	22,500	450	50	.71	x	.70	=	.50
250W	Vert.	24,000 +	12,100	300	40	.74	x	.70	=	.52
175W	Vert.	24,000 +	8,600	210	41	.78	x	.70	=	.55
100W	Vert.	24,000 +	4,200	120	38	.67	x	.70	=	.47
75W	Vert.	16,000 +	2,800	99	32	.68	x	.70	=	.48
50W	Vert.	16,000 +	1,575	74	21	.68	x	.70	=	.48
40W	Vert.	16,000 +	1,140	61	19	.68	x	.70	=	.48
Fluorescent Lamps										
PL5 (or equiv.)		10,000 (h)	250	8	31	.70(i)	x	.65	=	.46
PL7 (or equiv.)		10,000 (h)	400	10	40	.70(i)	x	.65	=	.46
PL9 (or equiv.)		10,000 (h)	600	12	50	.70(i)	x	.65	=	.46
PL13 (or equiv.)		10,000 (h)	900	16	56	.70(i)	x	.65	=	.46
F40CWRS		20,000+(h)	3,150	48	66	.83	x	.65	=	.54
(M)F40LW/RS/II		20,000 (h)	2,925	40	73	.83	x	.65	=	.54
F40SP30/RS (or equiv.)		15,000 (h)	3,350	48	67	.83	x	.65	=	.54
(M)F40SP30/RS (or equiv.)		20,000 (h)	2,900	40	72	.83	x	.65	=	.54
F40SP35/RS (or equiv.)		20,000+(h)	3,250	48	66	.83	x	.65	=	.54
(M)F40SP35/RS (or equiv.)		20,000 (h)	2,900	40	72	.83	x	.65	=	.54
F40SP41/RS (or equiv.)		20,000+(h)	3,250	48	67	.83	x	.65	=	.54

Lamp Table (cont.)

Light Source	Burning Position	(a) Lamp Life	(b) Initial Lumens	Lamp & Ballast Wattage	Efficacy	(c) LLD	x	(d) LDD	=	(e) LLF
Fluorescent Lamps (Cont.)										
(M)F40SP41/RS (or equiv.)		20,000 (h)	2,900	40	71	.83	x	.65	=	.54
F40SPX30/RS (or equiv.)		20,000+(h)	3,275	48	68	.83	x	.65	=	.54
(M)F40SPX30/RS (or equiv.)		20,000 (h)	2,900	40	71	.83	x	.65	=	.54
F40SPX35/RS (or equiv.)		20,000+(h)	3,275	48	67	.83	x	.65	=	.54
(M)F40SPX35/RS (or equiv.)		20,000 (h)	2,900	40	71	.83	x	.65	=	.54
F96T12/CW (Slimline)		18,000	6,300	86	73	.89	x	.65	=	.58
(M)F96T12/LW (Slimline)		18,000	6,000	71	84	.89	x	.65	=	.58
F96T12/CW/HO (800MA)		18,000	9,200	121	76	.82	x	.65	=	.53
(M)F96T12/CW.HO (800MA)		18,000	8,300	106	78	.82	x	.65	=	.53
F96T12/CW/VHO (1500MA)		12,500	14,000	222	63	.67	x	.60	=	.40
(M)F96T12/LW/VHO (1500MA)		11,250	13,800	196	70	.67	x	.60	=	.40
F96PG17/CW (1500MA)		15,000	16,000	225	71	.67	x	.60	=	.40
(M)F96PG17/LW (1500MA)		15,000	14,900	196	76	.67	x	.60	=	.40
Quartz Tungsten Halogen Lamps										
1500W T-3	Horz. (n)	2,000	35,800	1500	24	.95	x	.65	=	.62
1000W T-3	Horz. (n)	2,000	21,500	1000	22	.95	x	.65	=	.62
500W T-3	Horz. (n)	2,000	11,100	500	22	.95	x	.65	=	.62
200W T-3	Horz. (n)	1,500	3,350	200	17	.95	x	.65	=	.62

Lamp Table (cont.)

Light Source	Burning Position	(a) Lamp Life	(b) Initial Lumens	Lamp & Ballast Wattage	Efficacy	(c) LLD	x	(d) LDD	=	(e) LLF
Low Pressure Sodium Lamps										
180W T-21		18,000	33,000	220	150	1.00	x	.65	=	.65
135W T-21		18,000	22,500	178	126	1.00	x	.65	=	.65
90W T-21		18,000	13,500	125	108	1.00	x	.65	=	.65
55W T-17		18,000	8,000	80	100	1.00	x	.65	=	.65
35W T-17		18,000	4,800	68	71	1.00	x	.65	=	.65
18W T-17		10,000	1,800	30	60	1.00	x	.65	=	.65

(a) Lamp life based: 10 hours per start for HID lamps and 12 hours per start for fluorescent unless otherwise noted.

(b) Initial lumens (after 100 hours).

(c) Lamp lumen depreciation at 70% rate life (LLD).

(d) Luminary dirt depreciation (LDD). **For outdoor luminaries only.**

(e) Light loss factor (LLF). **For outdoor luminaries only.**

(f) Average rate life 20,000 hours (when operated vertical ± 30). All other burning positions 15,000 hours.

(g) Average rated life 10,000 hours (when operated vertical ± 30). All other burning positions 6,000 hours.

(h) Average rated life at 3 hours per start.

(i) Estimated.

(j) Lamp must be operated within ± 15° of vertical.

(k) Lamp must be operated within ± 15° of horizontal. Requires special socket to accept position oriented base.

(l) High output lamps.

(m) Energy efficient lamps.

(n) Lamp must be operated within ± 4° of vertical.

Cooking Equipment

How to Evaluate Energy Cost

Electric Cost/yr = Nameplate rating (kW) * Diversity Factor (default of .25) * 12 * $/kW + kW * Diversity Factor * Hours per year * $/kWh

-OR-

To estimate further (this is a reasonable estimate, since cooking will be a flat load throughout the year):

Electric Cost/yr = kW * Diversity Factor * Hours per year * Average $/kWh (from Table below)

Gas Cost/yr = Nameplate rating (Btuh) * Diversity Factor (default of .35) * Hours per year * $/therm /100000 Btu per therm

Equipment Input, Diversity, and Preheat Times

Equipment Type	Diversity (Elec/Gas)		Typical Input		Preheat Time, min.	
	Electric	Gas	Electric (kW)	Gas (Btuh)	Electric	Gas
Fryer (conventional), 45#	.20	.39	14	120000	5-8	8-12
Griddle, 3'	.20	.40	9	90000	7-12	10-15
Deck Oven, 2-pan 5'	.20	.39	10	75000	20-36	45-60
Convection Oven, Single Full-Size	.18	.35	11	55000	9-10	20-30
Conveyor Oven, 36"	.25	.45	18	120000	20-40	30-40
Tilting Skillet, 40 gal.	.20	.39	18	100000	8-13	5-9
Solid Top Range, 3'	.30	.80	8	80000	7-15	10-30
Range Oven, 1 pan	.20	.39	5	35000	20-36	20-30
Radiant Broiler, 3'	.60	.95	12	50000	5-10	15-20
Charbroiler, 3'	.60	.95	12	50000	8-11	20
Steam Jacketed Kettle, 40 gal.	.20	.45	18	110000	10-20	10-20

Note that diversity is different between electric and gas because of reheat, thermal efficiency, and operational differences.

Business Type	Typical Electric Costs ($/kWh)	Typical Gas Costs ($/therm)
Fast Food	.085	1.35
Full Service	.095	1.4
Cafeteria	.095	1.4
Church/Synagogue	.1	1.45
Large Office Building	.05	1.25
School (K-12)	.085	1.2
College/University	.08	1.3
Healthcare	.085	1.2

Effective 10/2002. Check powerzone@georgiapower.com for updated information.

Cooking Efficiency

Equipment	Electric	Gas
Broiler, over fired	.52	.22
Charbroiler	.65	.16
Fryer, conventional	.78	.28
Fryer, pressure	.83	.3
Griddle, grooved	.71	.51
Kettle, jacketed	.73	.42
Open range burner	.73	.38
Oven, convection	.62	.28
Oven, deck	.55	.24
Oven, range	.45	.13
Skillet, tilting	.79	.52
Steamer, convection	.23	.13
Steamer, pressure	.39	.19

Note: This represents the energy that is put into the food (as opposed to the kitchen or up the flue). Source: "Comparative gas/electric foodservice equipment energy consumption ratio study", University of Minnesota, 3/3/83, p. 12. O.P. Snyder, D.R. Thompson, J.F. Norwig.

Ventilation Requirements (CFM per SF of Cooking Surface)

Equipment	Electric	Gas
Ovens, Steamers, Kettles	20	25
Fryers	35	60
Griddles and Ranges	35	40
Hot Top Ranges	85	100
Salamanders, High Broilers	60	70
Grooved Griddles	65	75
Char-Broilers	75	150

For every 250 CFM reduction, AC load is reduced by 1.1 tons and heating requirement is reduced by 13,200 Btuh.

Equipment Considerations

Typical Foodservice Budgets	Burger Chains	Family Restaurant
Food Sales	100%	100%
FOOD COST	33.3	31.5
LABOR COST, BENEFITS	24	29.1
Pretax Profits	24	29.1
Rent, Property Tax, Insurance	8	7.9
Administration, General	6	6.5
Advertising, Promotion	4.8	2.6
UTILITIES	3.6	0.48
Supplies	4	3.2
Repair, Maintenance, Int.	3.1	2.6
Depreciation	2.8	2.8

Utilities represent less than 5% of a restaurant's operating budget.

Electric foodservice equipment has the following advantages:

Savings in Food

1. Less shrinkage in meat roasting
2. Significant savings in frying fat
3. Less spoilage due to overcooking
4. Less spoilage due to uneven heating
5. Longer holding of food is possible
6. Larger servings from the griddle
7. Elimination of crippled baking runs

Savings in Labor

1. No pilot lights to relight
2. Less scrubbing of pots and pans
3. Fast recovery speeds production
4. Watching of food is minimized
5. Requires less skilled help
6. Minimum of supervision
7. Compact layout saves space

Other savings provided by electric cooking

1. The cooking process is energy efficient only 50% of typical gas BTUs
2. This results in cooler kitchens, less or no A/C, more efficient employees
3. The equipment lasts longer
4. Does not require a flue
5. It is easier to balance the building's air flow
6. Ovens are insulated on all six sides to conserve energy
7. Electricity is clean, providing for lower building maintenance costs
8. Water vapor and resulting humidity (bacteria, molds) are reduced
9. Equipment does not lose its efficiency with age
10. Kitchen design is easier and more flexible

Typical Equipment List Prices

Equipment	Electric	Gas
Braising Pan, 40 gal.	$20,223	$24,270
Charbroiler	$4,908	$5,152
Griddle, 3'	$4,910	$5,260
Fryer, 45 lb.	$5,485	$5,977
Kettle, 40 gal.	$19,563	$25,743
Oven, Combination	$26,129	$33,578
Oven, Double Convection	$20,695	$22,575
Pasta Cooker	$12,308	$14,000
Range	$8,588	$5,726
Steamer, 5-pan	$11,449	$16,679

As of 4/1/2008 Per autoquotes manufacturers suggested retail price (msrp)

Refrigerants and Chillers

Common Refrigerants, Applications, and Current Status

No.	Name	Application	Status
11	Trichlorofluoromethane	Chillers (old)	No longer manufactured, still available
12	Dichlorodifluoromethane	Chillers (old)	No longer manufactured, still available
22	Chlorodifluoromethane	Small equipment, heat pumps, A/C units, cars	Phaseout scheduled for 2010
123	Dichlorotrifluoroethane	New chillers	Current
134a	Tetrafluoroethane	New chillers, cars, heat pumps	Current
717	Ammonia	Food processing, low-temperature applications	Current
410a	R32/R125 (50/50 blend), marketed as Puron	Small equipment, heat pumps, A/C units, cars	Current
407c	R32/R125/R134a (23/25/52 blend)	Chillers	Current

Chiller Types, Applications, Considerations

Type	Application	Considerations
Centrifugal, Water-cooled	High-rises; large applications (150t+)	Are most efficient run at full load; lose efficiency rapidly at partial loading
Reciprocating	100-120 t.	Lower capital expense; less efficient than most alternatives
Screw, Water-cooled	75-300 t.	Good efficiency at partial loading; can be noisy
Absorption	Industrial, 800-1000 t.	Not generally economic unless free steam is available.
Reciprocating and scroll, air-cooled	100-300 t.	Lower upfront cost, lower installation, doesn't require building space, less efficient than water-cooled

Motors and Pumps

Motor Basics

There are several terms used in motor applications. These include slip, motor efficiency, torque, and synchronous speed. The definitions of these terms are included in the glossary.

Within the AC motor category, there are 2 main categories:

- Single phase
- 3-phase

Single phase motors are typically used in applications of 1 horsepower or less. Three-phase motors are used for larger applications that don't require a DC motor. The allowable slip for the three-phase motors varies depending on the application. The speed listed on the motor is typically the actual speed (which takes slip into account). NEMA categorizes motors based on torque; we show the applications below:

NEMA Design	**B**	**C**	**D**
Locked Rotor Torque	Medium	High	Very High
Breakdown Torque	High	Medium	Low
% slip, max.	5%	5%	5% or more
Applications	Constant load speed, low inertia starts. Fans, compressors, conveyors, etc.	Constant load speed, high inertia starts Flywheels, large blowers, etc.	Variable load speed, high inertia starts. Hoists, elevators, some industrial equipment (punches, some presses).

Code Letter	kVa/hp	Code Letter	kVa/hp
A	0.0 - 3.15	L	9.0 - 10.0
B	3.15 - 3.55	M	10.0 - 11.2
C	3.55 - 4.0	N	11.2 - 12.5
D	4.0 - 5.0	P	12.5 - 14.0
E	4.5 - 5.0	R	14.0 - 16.0
F	5.0 - 5.6	S	16.0 - 18.0
G	5.6 - 6.3	T	18.0 - 20.0
H	6.3 - 7.1	U	20.0 - 22.4
J	7.1 - 8.0	V	22.4 and up
K	8.0 - 9.0		

The nameplate code rating is a good indication of the starting current the motor will draw. A code letter at the beginning of the alphabet indicates a low starting current and a letter at the end of the alphabet indicates a high starting current. Starting current can be calculated using the following formula:

Starting current = (1000 x hp x kVa/hp)/(1.73 x Volts)

Motor Cost Comparison

Choosing the right motor is an important part of the design process. There is no "rule of thumb" for all motor types. To determine the annual operating cost and the best choice, you need to consider:

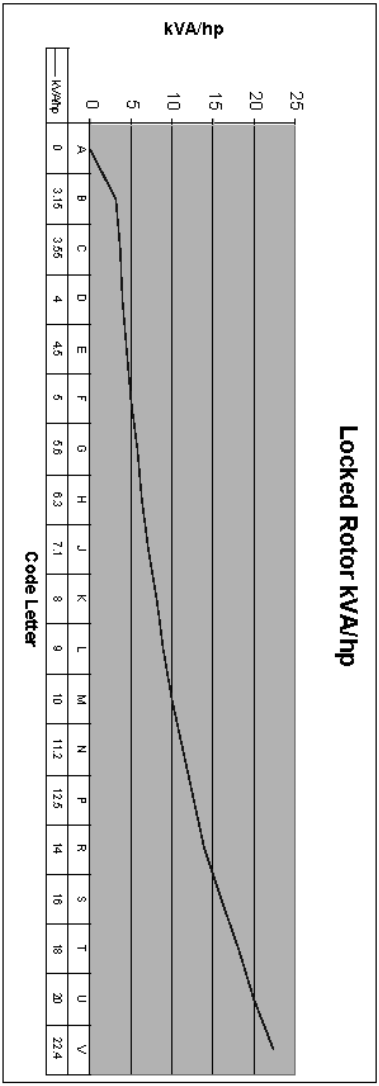
- Annual hours of operation
- Loading
- Electric rate
- Capital cost of the various options

The formula for the total cost would be:

Demand cost = hp under loading * 0.746 kW/hp* $/kW-month * 12 months/year / Efficiency

Energy cost = % loading * number of hours of operation * hp * 0.746 kW/hp * $/kWh / Efficiency

Total cost = demand cost + energy cost



Code Letter	A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	S	T	U	V
kVA/hp	0	3.15	3.55	4	4.5	5	5.6	6.3	7.1	8	9	10	11.2	12.5	14	16	18	20	22.4

Recommendation Chart for Motor Replacement/New Installation[3]

	5 hp	10 hp	15 hp	20 hp	30 hp
1000 hpy	Rewind/Std. Efficiency	Rewind/Std. Efficiency	Rewind/Std. Efficiency	Rewind/Std. Efficiency	Rewind/Std. Efficiency
3000	Rewind/High Eff.	Install New High Eff.	Install New High Eff.	Install New High Eff.	Install New High Eff.
5000	Rewind/High Eff.	Install New High Eff.	Install New High Eff.	Install New High Eff.	Install New High Eff.
7000	Install New High Eff.	Install New High Eff.	Install New High Eff.	Install New High Eff.	Install New High Eff.
8760	Install New High Eff.	Install New High Eff.	Install New High Eff.	Install New High Eff.	Install New High Eff.

3 Assumes small business tax rate, 15% discount rate, PLM rate schedule, standard and high efficiency as observed in supply catalogs, standard market prices. For any extensive motor replacements/installations, please contact Georgia Power to find the best customized decision

Heat Gain from Typical Electric Motors

Rated hp	Motor Type	Nominal rpm	Full-load Eff. %	Motor Insider; Equipment Inside (Btuh)	Motor Outside; Equipment Inside (Btuh)	Motor Inside; Equipment Outside (Btuh)
0.5	Split-phase	1750	60	2120	1270	850
0.75	3-phase	1750	72	2650	1900	740
1	3-phase	1750	75	3390	2550	850
1	3-phase	1750	77	4960	3820	1140
2	3-phase	1750	79	6440	5090	1350
3	3-phase	1750	81	9430	7640	1790
5	3-phase	1750	82	15500	12700	2790
7	3-phase	1750	84	22700	19100	3640
10	3-phase	1750	85	29900	24500	4490
15	3-phase	1750	86	44400	38200	6210
20	3-phase	1750	87	58500	50900	7610
25	3-phase	1750	88	72300	63600	8680
30	3-phase	1750	89	85700	76300	9440
40	3-phase	1750	89	114000	102000	12600

Heat Gain from Typical Electric Motors (cont.)

Rated hp	Motor Type	Nominal rpm	Full-load Eff. %	Motor Insider; Equipment Inside (Btuh)	Motor Outside; Equipment Inside (Btuh)	Motor Inside; Equipment Outside (Btuh)
50	3-phase	1750	89	143000	127000	15700
60	3-phase	1750	89	172000	153000	18900
75	3-phase	1750	90	212000	191000	21200
100	3-phase	1750	90	283000	255000	28300
125	3-phase	1750	90	353000	318000	35300
150	3-phase	1750	91	420000	382000	37800
200	3-phase	1750	91	569000	509000	50300
250	3-phase	1750	91	699000	636000	62900

Motor Formulae

Torque (lb-ft) = hp * 5250/RPM

Hp = Volts * Amps * Efficiency/746

% slip = (Synchronous RPM – Full-load RPM)*100/Synchronous RPM

Affinity Laws for Pumps

Impeller Diameter	Speed	Specific Gravity (SG)	To Correct for	Multiply by
Constant	Variable	Constant	Flow	$\left(\frac{\text{New Speed}}{\text{Old Speed}}\right)$
			Head	$\left(\frac{\text{New Speed}}{\text{Old Speed}}\right)^2$
			BHP (or kW)	$\left(\frac{\text{New Speed}}{\text{Old Speed}}\right)^3$
Variable	Constant	Constant	Flow	$\left(\frac{\text{New Diameter}}{\text{Old Diameter}}\right)$
			Head	$\left(\frac{\text{New Diameter}}{\text{Old Diameter}}\right)^2$
			BHP (or kW)	$\left(\frac{\text{New Diameter}}{\text{Old Diameter}}\right)^3$
Constant	Constant	Variable	BHP (or kW)	$\frac{\text{New SG}}{\text{Old SG}}$

Fans and Ducts

Fan Laws

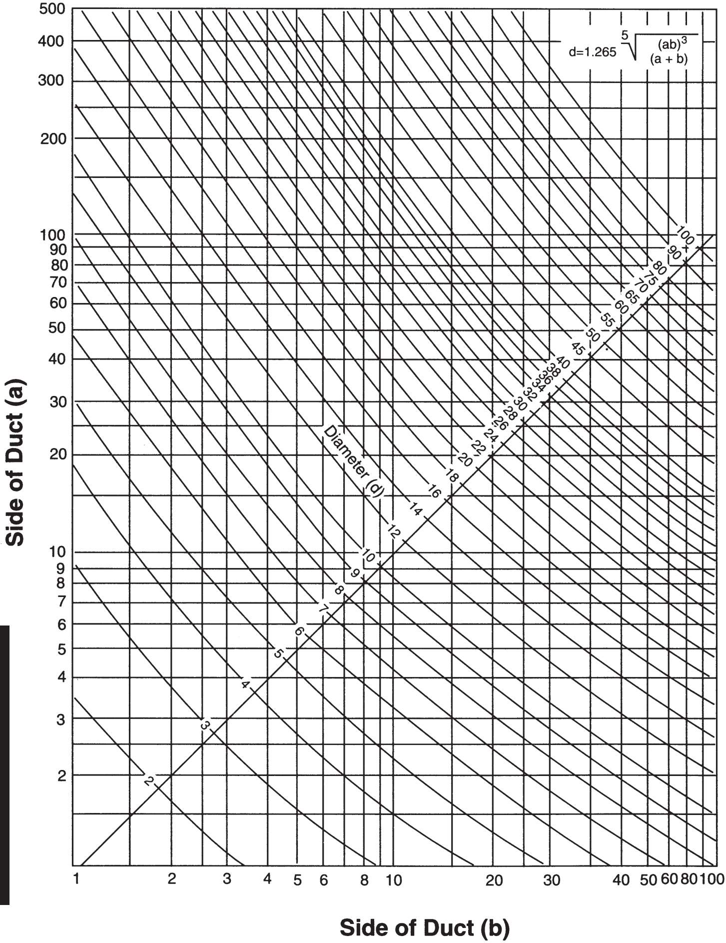
$CFM_1/CFM_2 = RPM_1/RPM_2$
$SP_1/SP_2 = (RPM_1/RPM_2)^2$
$HP_1/HP_2 = (RPM_1/RPM_2)^3$

Criteria for Fan Selection:

To get the best fan for a particular application, the designer must consider these aspects:

- Required air volume and static pressure
- Application type (temperature of discharge, corrosive vapors, etc.)
- Available space
- Noise criteria
- Location of discharge
- Motor position
- Air density (particularly important in South Georgia)

Rectangular Equivalent of Round Ducts



Industrial Applications

Compressed Air

Existing compressor capacity:

C = V(P2-P1)*60/(14.7*time)

Where:

C = capacity of compressor in cfm
V = receiver and piping volume in cu. ft.
P2 = final cutout pressure (absolute, psia)
P1 = initial pressure (absolute, psia)
Time = pump up time, in seconds

Additional Air Required = Existing Capacity * Desired Pressure/ Existing Pressure

Typical Compressor Capacity:

Type of Compressor	Piston, Two Stage	Rotary Screw
CFM per hp	3.5	4.0

Leakage Rate from Holes

Air Flow Through Orifices

Dia. of Orifice (in.)	Gauge Pressure in Receiver (pounds)													
	2	5	10	15	20	30	40	50	60	80	100	125	150	200
1/64	0.04	0.062	0.077	0.105	0.123	0.158	0.194	0.23	0.267	0.335	0.0406	0.494	0.583	0.75
1/32	0.158	0.248	0.311	0.420	0.491	0.633	0.774	0.916	1.06	1.34	1.62	1.98	2.23	3.18
3/64	0.356	0.568	0.712	0.944	1.10	1.42	1.75	2.06	2.38	3.0	3.66	4.44	5.25	6.86
1/16	0.633	0.993	1.24	1.68	1.96	2.53	3.10	3.66	4.23	5.36	6.49	7.90	9.1	12.17
3/32	1.43	2.23	2.80	3.78	4.41	5.69	7	8.25	9.5	12.0	14.6	17.8	20.9	27.35
1/8	2.53	3.97	4.98	6.72	7.86	10.1	12.4	14.7	16.9	21.4	26.0	31.6	37.3	48.7
3/16	5.7	8.93	11.2	15.2	17.65	22.8	28.0	33.0	38	48.3	58.5	71.0	84	109.6
1/4	10.1	15.9	19.9	26.9	31.4	40.5	49.6	58.6	67.6	85.7	104	126	149.3	195
3/8	22.8	35.7	44.7	60.5	70.7	91.1	112	132	152	193	234	284	336	438
1/2	40.5	63.5	79.6	108	126	162	198	235	271	343	415	506	596	777
5/8	63.03	99.3	124.5	168	196	253	310	366	423	536	649	790	932	1216
3/4	91.2	143	179.2	242	283	365	446	528	609	771	934	1138	1340	1750
7/8	124	195	244.2	329	385	496	607	718	828	1050	1272	1549	1825	2382
1	162	254	318.2	430	503	648	793	938	1082	1371	1661	2023	2385	3112
1-1/18	205	321	402.5	544	637	820	1004	1187	1370	1734	2101	2560	3020	3940
1-1/4	253	397	498	672	784	1019	1240	1464	1693	2144	2596	3160	3725	4860
1-3/8	307	482	604	816	954	1230	1505	1780	2054	2607	3153	3840	4525	5910
1-1/2	364	572	716	968	1132	1460	1783	2112	2335	3081	3734	4550	5360	7000
1-3/4	496	780	972	1318	1540	1985	2429	2875	3310	4200	5085	6195	7300	9530
2	648	1015	1274	1720	2120	2594	3173	3752	4330	5480	6650	8100	9540	12450

Note: For well-rounded entrance, mu8ltiply values by 0.97; for sharp-edged orifices, multiply by 0.65

Saturated Steam: Pressure Table

Abs. Press. (psi)	Temp (F)	Specific Volume			Enthalpy			Entropy			Abs. Press. (psi)
		Sat. Liquid	Evap.	Sat. Vapor	Sat. Liquid	Evap.	Sat. Vapor	Sat. Liquid	Evap.	Sat. Vapor	
p	t	v_f	v_{fg}	v_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g	p
0.08865	32.018	0.016022	3302.4	3302.4	0.0003	1075.5	1075.5	0.0000	2.1872	2.1872	0.8865
0.25	59.323	0.016032	1235.5	1235.5	27.382	1060.1	1087.4	0.0542	2.0425	2.0967	0.25
0.5	79.586	0.016071	641.5	641.5	47.623	1048.6	1096.3	0.0925	1.9446	2.0370	0.5
1.0	101.74	0.01636	333.59	333.6	69.73	1036.1	1105.8	0.1326	1.8455	1.9781	1.0
5.0	162.24	0.016407	73.515	73.532	130.2	1000.9	1131.1	0.2349	1.6094	1.8443	5.0
10.0	193.21	0.016592	38.404	38.420	161.26	982.1	1143.3	0.2836	1.5043	1.7879	10.0
14.696	212.00	0.016719	26.782	26.799	180.17	970.3	1150.5	0.3121	1.4447	1.7568	14.696
15.0	213.03	0.016726	26.274	26.290	181.21	969.7	1150.9	0.3137	1.4415	1.7552	15.0
20.0	227.96	0.016834	20.070	20.087	196.27	960.1	1156.3	0.3358	1.3962	1.7320	20.0
30.0	250.34	0.017009	13.7266	13.7436	218.9	945.2	1164.1	0.3682	1.3313	1.6995	30.0
40.0	267.25	0.017151	10.4794	10.4965	236.1	933.6	1169.8	0.3921	1.2844	1.6765	40.0
50.0	281.02	0.017274	8.4967	8.5140	250.2	923.9	1174.1	0.4122	1.2474	1.6586	50.0
60.0	292.71	0.017383	7.1562	7.1736	262.2	915.4	1177.6	0.4273	1.2167	1.6440	60.0
70.0	302.93	0.017482	6.1875	6.2050	272.7	907.8	1180.6	0.4411	1.1905	1.6316	70.0
80.0	312.04	0.017573	5.4536	5.4711	282.1	900.9	1183.1	0.4534	1.1675	1.6208	80.0
90.0	320.28	0.017659	4.8779	4.8953	290.7	894.6	1185.3	0.4643	1.1470	1.6113	90.0
100.0	327.82	0.017740	4.4133	4.4310	298.5	888.6	1187.20	0.4743	1.1284	1.6027	100.0
110.0	334.79	0.01782	4.0306	4.0484	305.8	883.1	1188.9	0.4834	1.1115	1.5950	110.0
120.0	341.27	0.01789	3.7097	3.7275	312.6	877.8	1190.4	0.4919	1.0960	1.5879	120.0
130.0	347.33	0.01796	3.4364	3.4544	319.0	872.8	1191.7	0.4998	1.0815	1.5813	130.0
140.0	353.04	0.01803	3.2010	3.2190	325.0	868.8	1193.0	0.5071	1.0681	1.5752	140.0

Saturated Steam: Pressure Table (cont.)

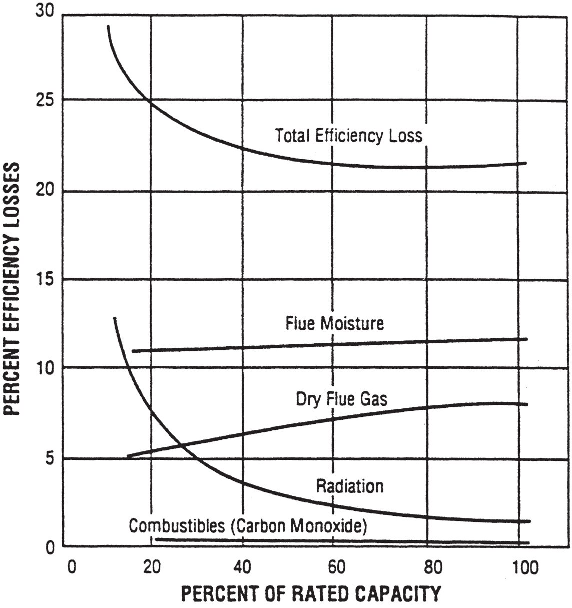
Abs. Press. (psi)	Temp (F)	Specific Volume			Enthalpy			Entropy			Abs. Press. (psi)
		Sat. Liquid	Evap.	Sat. Vapor	Sat. Liquid	Evap.	Sat. Vapor	Sat. Liquid	Evap.	Sat. Vapor	
p	t	v_f	v_{fg}	v_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g	p
150.0	358.43	0.01809	2.9958	3.0139	330.6	863.4	1194.1	0.5141	1.0554	1.5695	150.0
160.0	363.55	0.01815	2.8155	2.8336	336.1	859.0	1195.1	0.5206	1.0435	1.5641	160.0
170.0	368.42	0.01821	2.6556	2.6738	341.2	854.8	1196.0	0.5269	1.0322	1.5591	170.0
180.0	373.08	0.01827	2.5129	2.5312	346.2	850.7	1196.9	0.5328	1.0215	1.5543	180.0
190.0	377.53	0.01833	2.3847	2.4030	350.9	846.7	1197.6	0.5384	1.0113	1.5498	190.0
200.0	381.80	0.01839	2.2689	2.2873	355.5	842.8	1198.3	0.5438	1.0016	1.5454	200.0
210.0	385.91	0.01844	2.16373	2.18217	359.9	839.1	1199.0	0.5490	0.9923	1.5413	210.0
220.0	389.88	0.01850	2.06779	2.08629	364.2	835.4	1199.6	0.5540	0.9834	1.5374	220.0
230.0	393.70	0.01855	1.97991	1.99846	368.3	831.8	1200.1	0.5588	0.9748	1.5366	230.0
240.0	397.39	0.01860	1.89909	1.91769	372.3	828.4	1200.6	0.5634	0.9665	1.5299	240.0
250.0	400.97	0.01865	1.82452	1.84317	376.1	825.0	1201.1	0.5679	0.9585	1.5264	250.0
260.0	404.44	0.01870	1.75548	1.77418	379.9	821.6	1201.5	0.5722	0.9508	1.5230	260.0
270.0	407.80	0.01875	1.69137	1.71013	383.6	818.3	1201.9	0.5764	0.9433	1.5197	270.0
280.0	411.07	0.01880	1.63169	1.65049	387.1	815.1	1202.3	0.5805	0.9361	1.5166	280.0
290.0	414.25	0.01885	1.57597	1.59482	390.6	812.0	1202.6	0.5844	0.9291	1.5135	290.0
300.0	417.35	0.01889	1.52384	1.54274	394.0	808.9	1202.9	0.5882	0.9223	1.5105	300.0
350.0	431.73	0.01912	1.30642	1.32554	409.8	794.2	1204.0	0.6059	0.8909	1.4968	350.0
400.0	444.60	0.01934	1.14162	1.16095	424.2	780.4	1204.6	0.6217	0.8630	1.4847	100.0

Steam Loss from Leaks*

Trap Orifice Diameter (inches)	Pressure (psi)			
	15	100	150	300
1/32	0.85	3.3	4.8	9.8
1/16	3.4	13.2	18.9	36.2
1/8	13.7	52.8	75.8	145.0
3/16	30.7	119.0	170.0	326.0
1/4	54.7	211.0	303.0	579.0
3/8	123.0	475.0	682.0	1303.0

**in lb/hr.*
A typical plant has a steam value of $5/1000 lbs. steam

Combustion Heat Losses, Gas Boilers



Industrial Process Technologies

Technology	Applications	Considerations
Ultraviolet	Coatings on heat sensitive substrates. Disinfection in water/ sewage treatment.	Fast curing. No VOCs. Low maintenance.
Induction	Electrically conductive work pieces – high frequency for surface hardening, low for through heating.	Best for symmetric shapes and high productivity applications.
Plasma Arc	Cutting, welding, melting, incineration, vitrification.	More accurate and faster than mechanical cutting
Radio Frequency	Rapid drying of non-conductive materials. Adhesive curing. Plastics welding.	Best for difficult drying applications, bound moisture removal
Microwave	Cooking and final drying of foods. Rubber vulcanization. Sintering ceramics.	New microwave technologies allow web drying applications. Best for high value-added products (high capital cost).
Infrared	Comfort heating. Process heating.	Great in areas with high ventilation (comfort application); increases drying speed – increasing productivity (process).
Powder Coating	Painting.	No VOCs. Higher quality. Good application for IR curing.
Ozonation	Laundry brightening. Water disinfection.	No bleach required.
Electrode Boilers	Steam, hot water production.	Rapid startup. High capacity. Small footprint. No exhaust flue. High efficiency. Low noise. Precise control.

Industrial Heating and Curing

Typical Energy Requirements (kWh/ton)

Process	Steel	Stainless Non-Magnetic	Stainless Magnetic	Nickel	Titanium	Copper	Brass	Aluminum
Melting	500	550	550	500	400	370	350	450
Heat Forging	400	375	430	450	375	350	325	300
Hardening/ Solution Treating	250	260	N/A	300	325	350	300	300
Annealing	250	210	375	400	300	N/A	250	260
Warm Forming	175	N/A	250	240	N/A	N/A	N/A	N/A
Stress Relief	150	150	200	250	225	200	200	210
Tempering/ Aging	70	70	100	120	110	N/A	N/A	N/A
Curing	50	50	75	90	80	N/A	70	125

Information to Assess Induction Feasibility

Characteristic	Good Induction Application
Materials	Electrically conductive (typically metallic)
Coatings	Don't require long residence time for curing
Production	High volume/high speed
Heat Control	Requires ability to control temperature and depth of heating precisely
Scrap	Material that oxidizes readily (e.g. aluminum); induction allows control of atmosphere, moisture, and temperature — can reduce scrap rate from 7-8% to 1%
Floor Space	Little available square footage
Energy Costs	Moderate to high gas prices/moderate to low electric prices
System Efficiency	Processes that require sporadic heating; induction can cycle whereas gas convection cannot — result is lower energy use for induction
Product Shape	Simple, symmetric, regular
Capital Cost	Less important to customer; induction tends to cost more upfront, but can have rapid payback depending on application
Labor Cost	High labor costs; induction lends itself to automation which can reduce labor requirements in a plant

For help assessing induction for your customer, contact powerzone@georgiapower.com

Average Induction Heating System Efficiency

Type	Frequency	System Efficiency
Line Voltage	60 Hz	65%
Solid State	60 to 200 kHz	70%
Radio Frequency	200 to 450 kHz	50%

Emitters and Applications of IR Radiant Heating

	SHORT WAVE (High Intensity)	MEDIUM WAVE	LONG WAVE (High Intensity)
Type of Emitter	Tungsten filament lamps T-3 quartz lamps	Coil or wire in unsealed quartz, silicon tubes, or panels Metal radiant tubes Metal ribbon emitters Ceramic emitters	Glass panels Vitrified ceramic panels
Typical Applications	Curing painted surfaces Curing powder coatings Polymerization of organic coatings on cooking utensils Gelling PVC coatings on fabric Drying iron oxide on recording tapes Production of TV tubes Drying porcelain and ceramics Drying and production of glass-plastic composites	Curing painted surfaces Curing powder coatings Drying/heat setting fabrics after dyeing or printing Supplemental heater for paper drying Drying inks in printing or silkscreening Preheating plastic Preheating wooden panels prior to coating Curing coatings on wooden panels Curing the varnish or paints on mirror backs	Activating adhesives Drying textiles Animal care in agriculture Printed circuit board processing Drying silkscreen inks Preheating plastic Preheating embossing rollers Drying paints and lacquers

Typical Oven Comparison

	ELECTRIC	GAS CONVECTION
Floor space (conveyer length needed)	25 to 30 feet	300 to 350 feet
Warm-up time	1 to 90 seconds	30 minutes
Cure time	1 second to 10 minutes	20 to 35 minutes
Efficiency	45 to 60%	15 to 25%
Product temperature range	0 to 1000°F.	0 to 450°F.
Operational advantages	Can be turned off or reduced to 5-10% power with no parts in the oven	Runs all the time
Ease of installation	Preassembled, move into position	Erect on site

Properties of Solids

Metals

Substance	Specific Heat Btu/lb/F	Heat of Fusion Btu/lb	Melting Point (lowest) °F	Density lb/ft³	Density lb/in³	Thermal Conductivity Btu/hr/ft²/°F	Linear Coefficient of Thermal Expansion per °F x 10^0
Aluminum 1100	.24	169	1190	169	.098	128	13.1
Aluminum 2024	.24	167	935	173	.100	112	12.9
Aluminum 3003	.24	167	1190	170	.099	112	12.9
Antimony	.052	69	1166	423	.245	10.9	4.7-6.0
Bismuth	.031	23	520	610	.353	4.9	7.4
Brass (70% Cu. 30% Zn)	.10	—	1700 ±	525	.304	56	11.1
Copper	.10	91	1981	550	.318	224	9.2
Gold	.030	29	1945	1203	.697	169	7.9
Incoloy 800	.12	—	2475	501	.290	8.1	7.9
Incoloy 600	.11	—	2470	525	.304	9.1	7.4
Invar	.13	—	2600	508	.294	6.1	0.6
Iron, cast	.13	—	2300 ±	450	.260	33	6.5
Iron, wrought	.12	—	2800 ±	480	.278	36	6.5
Lead, solid	.031	10	621	710	.411	20	16.3
Lead, melted	.04	—	—	665	.385	—	—
Magnesium	.232	160	1202	109	.063	91	14
Monel 400	.11	—	2370	551	.319	14	7.7
Nickel 200	.11	133	2615	554	.321	39	7.4
Nichrome (80% Ni; 20% Cr)	.11	—	2550	524	.303	8.7	7.3
Platinum	.032	49	3224	1338	.775	41	4.9
Silver	.057	38	1761	655	.379	242	10.9
Solder (50% Pb; 50% Sn)	.04	17	415	580	.336	26	13.1
Steel, mild carbon	.12	—	255 ±	490	.284	38	6.7
Steel, stainless, 304	.11	—	2550	488	.282	8.8	9.6
Steel, stainless, 430	.11	—	2650	475	.275	12.5	6.0
Tantalum	.036	—	5425	1036	.600	31	3.6
Tin, solid	.056	25	450	455	.263	36	13
Tin, melted	.064	—	—	437	.253	18	—
Titanium	.126	—	3300	283	.164	9.3	4.7
Type Metal (85% Pb; 15% Sb)	.040	15	500	670	.388	—	—
Zinc	.095	51	787	445	.258	65	9.4-22

Solid Non-Metals

Properties of Solids

Substance	Specific Heat Btu/lb/F	Heat of Fusion Btu/lb	Melting Point (lowest) °F.	Density lb/ft³	Density lb/in³	Thermal Conductivity Btu/hr/ft²/°F	Linear Coefficient of Thermal Expansion per °F x 10⁰
Asbestos	.25	—	—	36	.028.087	—	
Asphalt	.40	40	250 ±	65	.038–	—	
Beeswax	—	75	144	60	.035–	—	
Brickwork & Masonry	.22	—	—	140	.081.38	3–6	
Carbon	.204	—	6700	—	.08013.8	.3–2.4	
Glass	.20	—	2200 ±	165	.096.45	5	
Graphite	.20	—	—	130	.075.104	—	
Ice	.46	—	—	57	.0331.28	—	
Magnesium Oxide							
before compaction	.21	—	—	—	—	.3	
compacted	.21	—	—	—	.1121.2	7.7	
Marinite-36 @ 600 F	.31	—	—	36	.021.068	1.3	
Mica	.20	—	—	—	.102.25	18	
paper	.45	—	—	58	.034.068	—	
Paraffin	.70	63	133	56	.032.13	—	
Pitch, hard	—	—	300 ±	83	.048–	—	
Plastics							
ABS	.3-.4	—	—	—	.036.11–.19	32–72	
Cellulosic	.3-.5	—	—	—	.048.10–.20	55–83	
Epoxy	.25	—	—	—	.045.10–.12	25–36	
Fluoroplastic	.28	—	—	—	.077.14	46–58	
Nylon	.4	—	—	—	.040.14	.44	
Phenolic	.3-.4	—	—	—	.048.085	.38	
Polyethylene	.55	—	—	—	.033.19–.29	55–111	
Polystyrene	.32	—	—	—	.037.03–.08	17–111	
Vinyl	.2-.3	—	—	—	.050.07–.17	28–139	
Quartz	.21	—	3150	138	.080.80	.30	
Rubber	.40	—	—	95±	.055±	.087	340
Soil dry	.44	—	—	100	.058.035±	—	
Steatite	.20	—	—	—	.0941.7	5	
Sugar	.30	—	320	105	.061	—	
Sulfur	.203	17	230	125	.072.15	36	
Tallow	—	—	90 ±	60	.035	—	
Wood-oak	.45 ±	—	—	50	.029.12–.20	—	
Wood-pine	.45 ±	—	—	34	.020.06–.14	—	

Properties of Liquids

Substance	Specific Heat Btu/lb/°F	Heat of Vaporization Btu/lb	Boiling Point °F	Density lb/ft³	Density lb/gal
Acetic acid	.472	153	245	66	8.82
Alcohol	.65	365	172	55	7.35
Benzine	.45	166	175	56	7.49
Brine (25% NACl)	.81	730±	220±	74	9.89
Caustic soda (18% NaOH)	.84	800±	220±	75	10.03
Dowtherm A (at 450°F)	.518	42	495	55	7.35
Ether	.503	160	95	46	6.15
Freon 12 (Saturated liquid)	.24	62	-20	78.5	10.50
Glycerine	.58	—	554	79	10.58
Mercury	.033	117	675	845	112.97
Oil, cotton seed	.47	—	—	60	8.02
Oil, olive	.47	—	570±	58	7.75
Oil, petroleum	.51	—	—	56	7.49
Paraffin, melted	.71	—	750±	56	7.49
Potassium (at 1000°F)	.18	893	1400	44.6	5.96
Sodium (at 1000°F)	.3	1810	1638	51.2	6.84
Sulfur, melted	.234	652	601	—	—
Therminol FR-1 (at 450°F)	.36	—	650±	73.5	9.83
Turpentine	.41	133	319	54	7.22
Water	1.0	965	212	62.5	8.34

Source: Chromalox (5)

Properties of Gases and Vapors

Substance	Specific Heat at Constant Pressure Btu/lb/°F	Density at 70°F and Atmospheric Pressure lb/ft³	Thermal Conductivity at 32°F and Atmospheric Pressure Btu/hr/ft²/°F
Acetylene	.35	.073	.0108
Air	.237	.08	.014
Ammonia	.520	.048	.0175
Argon	.124	.1037	.00912
Carbon dioxide	.203	.123	.0085
Carbon monoxide	.243	.078	.0135
Chlorine	.125	.2	.0043
Ethylene	.4	.0728	.0101
Helium	1.25	.0104	.0802
Hydrogen	3.41	.0056	.0917
Methane	.6	.0447	.0175
Methyl chloride	.24	.1309	.0053
Nitric Oxide	.231	.0779	.0138
Nitrogen	.245	.078	.014
Oxygen	.218	.09	.0142
Sulphur dioxide	.155	.179	.005
Water vapor (212°F)	.451	.0372	.0145

Source: Chromalox (5)

On-Site Generation and Power Quality

Standby Generation Considerations

Genset Fuel	Cost/kW	Fuel Tank?	Considerations
Diesel	$250	24-hour	If more than 500 kW standard generator, must have dykes to contain spill in amount of largest delivery tanker compartment.
Propane	<100 kW, $200 >100 kW, $400	Tank not furnished	Burns vapor, not liquid. Need a much larger tank to provide the required pressure.
Natural Gas	<100 kW, $200 >100 kW, $400	Not required	Must purchase firm gas contract if for backup of critical systems.

Uninterruptible Power Supply/Power Conditioning Systems

Solution Type	Protection Time	Size Range	Comments
Uninterruptible Power System (UPS): Battery (long term)	5-10 minutes typical protection with longer battery times available	650 VA to 750 kVA	Provides for proper operation of protected equipment for outages up to several minutes or seamless transfer to generator or orderly shutdown of protected equipment before the battery power expires.

Uninterruptible Power Supply/Power Conditioning Systems *(cont.)*

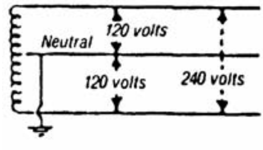
Solution Type	Protection Time	Size Range	Comments
UPS: Flywheel	13 seconds to 2 minutes based on power requirements of the protected system.	100 kVA to 750 kVA	Provides for orderly shutdown of protected equipment for short duration outages or provides seamless transfer to generator.
UPS: Battery (short-term)	30 seconds at 100% load and up to 60 seconds at partial load	313 kVA to 2500 kVA	Provides for orderly shutdown of protected equipment for short duration outages or provides seamless transfer to generator.
Dynamic Sag Corrector	Sag correction- 2 seconds maximum Momentary outages up to 12 cycles	250 VA to 3000 kVA	Protects against 92% of voltage events.
Surge Protection	N/A	N/A	Surge capacity and options vary with model. Protects systems from transient voltages such as lightning, switching transients and over-voltages.

Alternative Energy Sources

Type	Potential In SE	Cost/kW	Cost/kWh	Comments
Fuel Cell	High	$5000	Cost of fuel/efficiency	Works by converting natural gas to hydrogen.
Micro-turbine	High	$1000 (standard); $1400 (combined heat and power).	Must evaluate system efficiency. At 2002 gas prices, about $0.10/kWh.	Cost/kW at fully rated capacity. Cannot use this capacity for cost calculations – must derate for temperature
Wind-power	Low	$1000-1200	Free, except land and maintenance cost.	Only a few mountain ridges in N. Ga provide any wind potential.
Active Solar	Low (13% of energy delivered)	$1000-1200	Free, except land (if applicable) and maintenance cost	SE US listed by DOE as low potential location.
Waste-to Energy	Med-High	Location & size specific, $200/kW.	Fuel-specific	Industrial application. Requires extensive permitting and design. Best applications have fuel with no retail value and steam requirements in plant.

Electrical Distribution

Transformer secondary

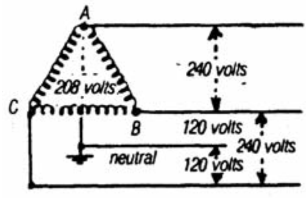


For single-phase light and power branch circuits.

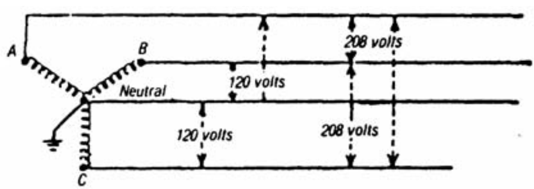
Single-phase, 3-wire

For three-phase power circuits and single-phase light and power branch circuits.

Three-phase, 4-wire delta with one phase center tapped and grounded. (Three-phase, 3-wire delta for power loads is used with a separate single phase supply for lighting.

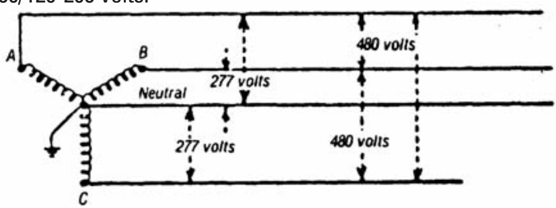


For three-phase power circuits and single-phase light and power branch circuits.



Three-phase, 4-wire wye (or star) with grounded neutral rated 120/208 volts.

For three-phase power circuits and lighting circuits using 277-volt ballasts. 120-volt lighting and receptacle loads are fed from this system through single-phase transformers rated 480/-120 240 volts or three-phase transformers rated 480/120-208 volts.



Three-phase, 4-wire wye (or star) with grounded neutral rated 277/480 volts.

Useful Electrical Formulas for Determining Amperes, Horsepower, Kilowatts, and kVa

To Find	Direct Current	ALTERNATING CURRENT Single Phase	ALTERNATING CURRENT Three Phase
Amperes when Horsepower is known	$\frac{\text{Hp. x 746}}{\text{E x Eff.}}$	$\frac{\text{Hp. x 746}}{\text{E x Eff. x P.F.}}$	$\frac{\text{Hp. x 746}}{\text{1.73 x E x Eff. x P.F.}}$
Amperes when Kilowatts is known	$\frac{\text{kW x 1000}}{\text{E}}$	$\frac{\text{kW x 1000}}{\text{E x P.F.}}$	$\frac{\text{kW x 1000}}{\text{1.73 x E x P.F.}}$
Amperes when kVa is known		$\frac{\text{kVA x 1000}}{\text{E}}$	$\frac{\text{kVA x 1000}}{\text{1.73 x E}}$
Kilowatts	$\frac{\text{I x E}}{\text{1000}}$	$\frac{\text{I x E x P.F.}}{\text{1000}}$	$\frac{\text{I x E x 1.73 x P.F.}}{\text{1000}}$
kVA		$\frac{\text{I x E}}{\text{1000}}$	$\frac{\text{I x E x 1.73}}{\text{1000}}$
Horsepower—(output)	$\frac{\text{I x E x Eff.}}{\text{746}}$	$\frac{\text{I x E x Eff. X P.F.}}{\text{746}}$	$\frac{\text{I x E x 1.73 x Eff. x P.F.}}{\text{746}}$

I = Amperes; E = Volts; Eff. = Efficiency expressed as decimal; P.F. = Power Factor; kW = Kilowatts; kVA = Kilovolt-amperes; Hp = Horsepower

Estimating Loads From kWh Meter Clocking

$$\text{kW} = \frac{\text{No. of Revolutions x 3600 x } K_h \text{ x C.T. Ratio}}{\text{1000 x Time in Seconds}}$$

Kh = Meter Constant; C.T. Ratio = Multiplier, if used

Effects From Voltage Variations

Motor Characteristics	90%	110%	120%
	% of Rated Voltage		
Torque	-19%	+21%	+44%
F. L. R. P. M.	-1½%	+1%	+1.5%
F.L. Efficiency	-2 Points	+½ Point	+1 Point
F.L. Amps	+11%	-7%	-.11%
Starting Amps	-10%	+10%	+.25%
F.L. Temperature	+11%	-6%	9%
Noise Level	-Slight	+Slight	+Noticeable
Max. Overloaded Capacity	-19%	+21%	+44%

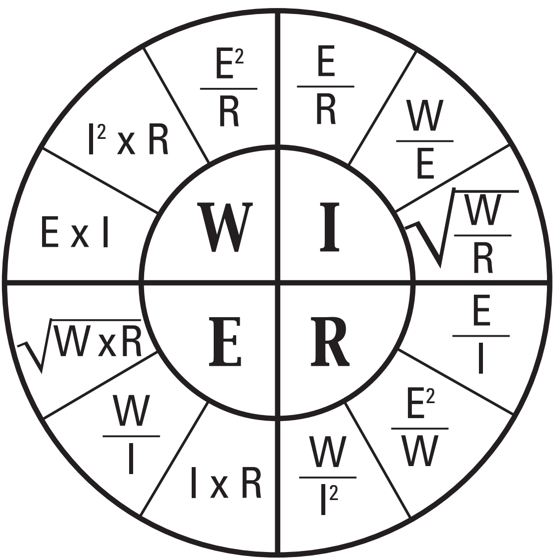
Percent of Rated Heater Watts at Reduced Voltage

240 Volt Heater on 230 Volts—92%
240 Volt Heater on 220 Volts—84%
240 Volt Heater on 208 Volts—75%
480 Volt Heater on 440 Volts—84%
480 Volt Heater on 277 Volts—33%

Motor Wattages

1/6 hp = 250 W	1/2 hp = 680 W
1/4 hp = 350 W	3/4 hp = 980 W
1/3 hp = 460 W	1 hp = 1200 W

Ohm's Law Made Easy



BTUH—kW—Amperes Chart

		120V	208V		240V		277V	480V	
BTUH	kW	1Ø	1Ø	3Ø	1Ø	3Ø	1Ø	1Ø	3Ø
3,413	1	8.3	4.8	2.8	4.2	2.4	3.6	2.1	1.2
6,826	2	16.7	9.6	5.5	8.3	4.8	7.2	4.2	2.4
10,239	3	25.0	14.4	8.3	12.5	7.2	10.8	6.2	3.6
13,652	4	33.3	19.2	11.1	16.6	9.6	14.4	8.3	4.8
17,065	5	41.7	24.0	13.9	20.8	12.0	18.1	10.4	6.0
20,478	6	50.0	28.9	16.6	25.0	14.4	21.7	12.5	7.2
23,891	7	58.3	33.7	19.4	29.1	16.8	25.3	14.6	8.4
27,304	8	66.6	38.5	22.2	33.3	19.2	28.9	16.6	9.6
30,717	9	75.0	43.5	24.9	37.4	21.6	32.5	18.7	10.8
34,130	10	83.3	48.1	27.7	41.6	24.0	36.1	20.8	12.0
51,195	15	125.0	72.1	41.6	62.4	36.0	54.2	31.2	18.6
68,260	20	166.6	96.2	55.4	83.2	48.0	72.2	41.6	24.0
85,325	25	208.3	120.2	69.3	104.0	60.0	90.3	52.0	30.0
102,390	30	250.0	144.3	83.1	124.8	72.0	108.3	62.4	36.0
119,455	35	291.7	168.4	97.0	145.6	84.0	126.4	72.8	42.0
136,520	40	333.3	192.4	110.8	166.4	96.0	144.4	83.2	48.0
153,585	45	375.0	216.5	124.7	187.2	108.0	162.5	93.6	54.0
170,650	50	416.6	240.5	138.5	208.0	120.0	180.5	104.0	60.0

Formula for Calculating Line Currents

$$\text{AMPERES} = \frac{\text{SINGLE PHASE WATTS}}{\text{LINE VOLTAGE}}$$

$$\text{AMPERES} = \frac{\text{THREE PHASE WATTS}}{\text{LINE VOLTAGE X 1.73}}$$

TO CONVERT “kW” TO WATTS MULTIPLY “kW” BY 1,000

Transformer Types and Requirements

Service Voltage	**Maximum Size Padmounted Transformer (kVA)**
120/240V, single-phase, three-wire	167
120/240V delta, three-phase, four-wire	Overhead transformer service only
120/208V grounded wye, three-phase, four-wire	1000
277/480V grounded wye, three-phase, four-wire	2500

If the expected demand will exceed the maximum size transformer, you are asked to design a split bus/panel arrangement to accept service from more than one transformer.

Georgia Power Company must approve location of padmounted transformers before final design. The following requirements must be met:[1]

- The selected location must be conducive to the installation of underground primary electrical cables.
- The edge of the concrete pad nearest the building shall be:
  - No closer than 14 ft. from doorways
  - No closer than 10 ft. from building wall, windows or other openings. If the building is 3 stories or less, the 10-ft. clearance is measured from the edge of any overhang or canopy. Fire escapes, outside stairs, and covered walkways attached to or between buildings shall be considered part of the building.

[1]As of 10/02. See powerzone@georgiapower.com for most current information.

- Any exceptions to the above requirements must be approved by the local fire marshal or the jurisdiction having authority. Before seeking approval, contact Georgia Power Company to evaluate the feasibility of the exceptions. Written approval must be provided to Georgia Power Company.
- Transformers shall be located such that:
    - The front of the transformer faces away from the building
    - There are 10 ft. of clearance in front of the transformer doors
    - They are easily accessible by personnel and heavy equipment during construction and after project completion
    - If more than one padmounted transformer is required, the minimum spacing between transformers (including cooling fins) is 5 ft.
    - There is unrestricted air flow for cooling requirements. Trees, shrubs, and other similar vegetation must be kept at least 10 ft. from all sides of the transformer.

Item	Provided by	Comments/Restrictions
Overhead Service Conductors	Georgia Power	From transformer to customer's weatherhead
Single-phase underground service conductors	Georgia Power	Residential customers must pay a flat fee to receive underground service
Three-phase underground service from padmounted transformers	Customer	
Three-phase underground service from overhead transformers	Georgia Power	If LESS than 600A service

Item	Provided by	Comments/Restrictions
Three-phase underground service from overhead transformers	Customer	If MORE than 600A service
Service conductor connections in padmounted transformers, at weatherheads, and at metering equipment	Georgia Power	
Concrete transformer pads (contact Georgia Power for dimensional details)	Georgia Power	GPC will furnish and install. Customer's service conduits must be designed to fit within the secondary side of the pad opening

Requirements for Service Conductors

- All three-phase services from padmounted transformers must be 4-wire, grounded wye service
- The customer's service ground may NOT be terminated in the padmounted transformer compartment
- Three-phase services should have no more than 12 conductors per phase. If more than 12 are required, contact Georgia Power Company to discuss the feasibility of exceptions.

Motor Starting

Type of Service	Who Limits Starting Voltage Drop	Comments
Single Phase	Georgia Power	Responsible for both customer side and system side
Any customer with welding machines	Customer	Must design and install motor starting technology to limit starting voltage drop to the established acceptable values on both the customer's and system's side.
Three-Phase	Customer	Must design and install motor starting technology to limit starting voltage drop to the established acceptable values on both the customer's and system's side.

Other

- Available fault current depends on the size transformer and that transformer's impedance. Register your project at powerzone@georgiapower.com to get the available fault current for that location.
- Consult Georgia Power Company's current Electrical Service and Metering Installations for detailed information on metering and service installation requirements.

Miscellaneous

Diversity Factors for EFLH calculations

Equipment	Diversity Multiplier (demand)
Compressors (air conditioning)	1
Fans, air handlers	1
Lighting, interior	0.9
Lighting, exterior	0 (if before the meter)
Space heating	0.65
Cooking	0.35 (see cooking tables for specific items)
Water heating	0.5
Refrigeration	0.8
Miscellaneous	0.25

*This chart can be used to calculate the demand charges for various types of equipment. Demand seen by meter = Rated kW * Diversity.*
Remember to apply only during the months that the equipment would run!

Noise

Design Criteria for Room Loudness

Room Type	Sones	Room Type	Sones
Auditoriums		***Indoor sports activities***	
Concert and opera halls	1.0 to 3	Gymnasiums	4 to 12
Stage theaters	1.5 to 5	Coliseums	3 to 9
Movie theaters	2.0 to 6	Swimming pools	7 to 21
Semi-outdoor amphitheaters	2.0 to 6	Bowling alleys	4 to 12
		Gambling casinos	4 to 12
Lecture halls	2.0 to 6	***Manufacturing areas***	
Multi-purpose	1.5 to 5	Heavy machinery	25 to 60
Courtrooms	3.0 to 9	Foundries	20 to 60
Auditorium lobbies	4.0 to 12	Light machinery	12 to 36
TV audience studios	2.0 to 6	Assembly lines	12 to 36
Churches and schools		Machine shops	15 to 50
Sanctuaries	1.7 to 5	Plating shops	20 to 50
Schools and classrooms	2.5 to 8	Punch press shops	50 to 60
Recreation halls	4.0 to 12	Tool maintenance	7 to 21
Kitchens	6.0 to 18	Foreman's office	50 to 15
Libraries	2.0 to 6	General storage	10 to 30
Laboratories	4.0 to 12	***Offices***	
Corridors and halls	5.0 to 15	Executive	2 to 6
Hospitals and clinics		Supervisor	3 to 9
Private rooms	1.7 to 5	General open offices	4 to 12
Wards	2.5 to 8	Tabulation/computation	6 to 18
Laboratories	4.0 to 12	Drafting	4 to 12
Operating rooms	2.5 to 8	Professional offices	3 to 9
Lobbies & waiting rooms	4.0 to 12	Conference rooms	1.7 to 5
Halls and corridors	4.0 to 12	Board of Directors	1 to 3
		Halls and corridors	5 to 15

Note: Values shown above are room loudness in sones and are not fan sone ratings. For additional detail see AMCA publication 302 — Application of Sone Rating.

Noise

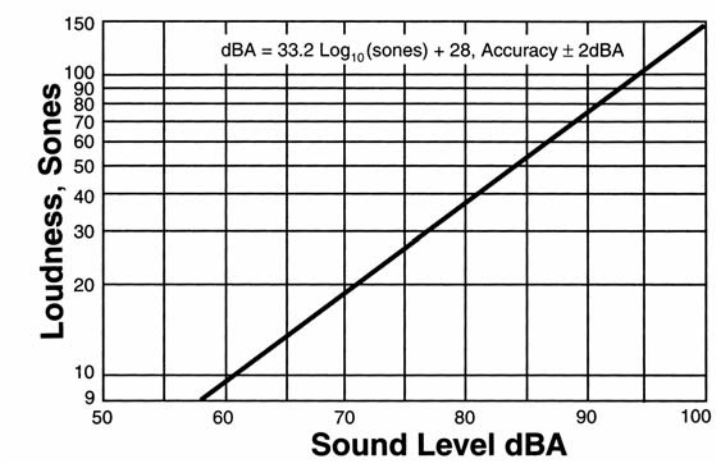
Design Criteria for Room Loudness (cont.)

Room Type	Sones
Hotels	
Lobbies	4.0 to 12
Banquet rooms	8.0 to 24
Ballrooms	3.0 to 9
Individual rooms/suites	2.0 to 6
Kitchens and laundries	7.0 to 12
Halls and corridors	4.0 to 12
Garages	6.0 to 18
Residences	
Two & three family units	3 to 9
Apartment houses	3 to 9
Private homes (urban)	3 to 9
Private homes (rural and suburban	1.3 to 4
Restaurants	
Restaurants	4 to 12
Cafeterias	6 to 8
Cocktail lounges	5 to 15
Social clubs	3 to 9
Night clubs	4 to 12
Banquet room	8 to 24
Miscellaneous	
Reception rooms	3 to 9
Washrooms and toilets	5 to 15
Studios for sound reproduction	1 to 3
Other studios	4 to 12

Room Type	Sones
Public buildings	
Museums	3 to 9
Planetariums	2 to 6
Post offices	4 to 12
Courthouses	4 to 12
Public libraries	2 to 6
Banks	4 to 12
Lobbies and corridors	4 to 12
Retail stores	
Supermarkets	7 to 21
Department stores (main floor)	6 to 18
Department stores (upper floor)	4 to 12
Small retail stores	6 to 18
Clothing stores	4 to 12
Transportation *(rail, bus, plane)*	
Waiting rooms	5 to 15
Ticket sales office	4 to 12
Control rooms & towers	6 to 12
Lounges	5 to 15
Retail shops	6 to 18

Note: Values shown above are room loudness in sones and are not fan sone ratings. For additional detail see AMCA publication 302 — Application of Sone Rating.

Room Sones – dBA Correlation



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ATLANTA/HARTSFIELD, GEORGIA

Lat. 33 39N Long. 84 26W Elev. 1,010 ft.

Mean Frequency of Occurrence of Dry Bulb Temperature (degrees F.) with Mean Coincident Wet Bulb (MCWB) Temperature (degrees F.) for Each Dry Bulb Temperature Range

Temperature Range	MAY Obsn Hour Gp 01 to 08	MAY 09 to 16	MAY 17 to 24	MAY Total Obsn	MAY MCWB	JUNE Obsn Hour Gp 01 to 08	JUNE 09 to 16	JUNE 17 to 24	JUNE Total Obsn	JUNE MCWB	JULY Obsn Hour Gp 01 to 08	JULY 09 to 16	JULY 17 to 24	JULY Total Obsn	JULY MCWB	AUGUST Obsn Hour Gp 01 to 08	AUGUST 09 to 16	AUGUST 17 to 24	AUGUST Total Obsn	AUGUST MCWB	SEPTEMBER Obsn Hour Gp 01 to 08	SEPTEMBER 09 to 16	SEPTEMBER 17 to 24	SEPTEMBER Total Obsn	SEPTEMBER MCWB	OCTOBER Obsn Hour Gp 01 to 08	OCTOBER 09 to 16	OCTOBER 17 to 24	OCTOBER Total Obsn	OCTOBER MCWB
100/104							0		0	77		1	0	1	72		0		0	76										
95/99							4	1	5	74		5	1	6	74		6	1	7	74		2	0	2	72		0		0	74
90/94		4	1	5	70		29	10	39	74		30	10	40	74		30	9	39	74		9	2	11	71		1	0	1	73
85/89		33	13	46	69	0	52	25	77	72	0	61	30	91	74		72	33	105	73		31	11	42	71		3	1	4	70
80/84	0	53	28	81	67	5	65	44	114	71	5	81	57	143	73	3	76	58	137	72	0	60	31	91	70		16	4	20	68
75/79	3	57	46	106	66	31	50	62	143	69	46	51	74	171	72	47	42	76	165	71	8	57	53	118	68	1	42	14	57	64
70/74	32	47	62	141	64	93	28	64	185	68	147	18	69	234	70	133	19	59	211	69	72	43	71	186	67	8	52	34	94	63
65/69	94	30	52	176	62	82	11	28	121	64	46	2	7	55	66	54	3	11	68	65	82	21	40	143	63	28	53	54	135	60
60/64	59	15	26	100	58	23	1	4	28	59	5	0	1	6	60	10	0	1	11	60	49	14	23	86	59	51	39	59	149	57
55/59	30	7	15	52	53	5	1	1	7	55						0			0	56	22	2	6	30	54	60	23	40	123	52
50/54	19	1	5	25	48	1		0	1	49											6	1	1	8	49	51	12	24	87	48
45/49	8	0	1	9	44	0			0	44											1		0	1	45	28	4	11	43	43
40/44	3	0	0	3	40																0			0	42	14	2	4	20	39
35/39																										7	0	1	8	33
30/34																										2		0	2	29

Temperature Range	NOVEMBER Obsn Hour Gp 01 to 08	09 to 16	17 to 24	Total Obsn	MCWB	DECEMBER Obsn Hour Gp 01 to 08	09 to 16	17 to 24	Total Obsn	MCWB	JANUARY Obsn Hour Gp 01 to 08	09 to 16	17 to 24	Total Obsn	MCWB	FEBRUARY Obsn Hour Gp 01 to 08	09 to 16	17 to 24	Total Obsn	MCWB	MARCH Obsn Hour Gp 01 to 08	09 to 16	17 to 24	Total Obsn	MCWB	APRIL Obsn Hour Gp 01 to 08	09 to 16	17 to 24	Total Obsn	MCWB	ANNUAL TOTAL Obsn Hour Gp 01 to 08	09 to 16	17 to 24	Total Obsn	MCWB
100/104																																1	0	1	73
95/99																																17	3	20	74
90/94																																103	2	135	74
85/89																											2	0	2	64	0	254	113	367	72
80/84		1	0	1	67																	1	0	1	64		17	7	24	64	13	370	229	612	70
75/79		5	1	6	64							0		0	64		2	0	2	63		9	4	13	62		38	20	58	62	136	353	350	839	69
70/74	0	20	5	25	60		3	0	3	60		4	1	5	63		8	3	11	60	0	18	9	27	59	2	41	36	79	61	487	301	413	1201	67
65/69	5	32	17	54	59	1	13	5	19	60	2	11	5	18	60	2	16	10	28	57	5	27	24	56	57	22	43	48	113	59	423	262	301	986	62
60/64	18	39	35	92	56	9	22	16	47	57	9	19	19	47	57	7	25	20	52	55	16	34	34	84	54	55	40	48	143	56	311	248	286	845	57
55/59	28	40	43	111	51	13	26	22	61	52	17	29	23	69	53	17	32	33	82	51	30	45	42	117	50	54	29	38	121	52	276	234	263	773	52
50/54	34	38	41	113	47	17	36	33	86	47	21	34	34	89	47	26	34	37	97	47	38	40	44	122	47	42	17	22	81	46	255	213	241	709	47
45/49	45	30	42	117	42	29	44	41	114	42	25	42	39	106	43	32	37	37	106	42	44	34	37	115	42	31	9	14	54	42	243	200	222	665	42
40/44	44	20	30	94	38	39	44	53	136	38	36	38	43	117	38	43	30	35	108	38	48	21	30	99	38	22	3	6	31	38	249	158	201	608	38
35/39	35	9	16	60	33	55	29	37	121	34	46	37	40	123	34	41	21	25	87	34	34	12	15	61	33	10	0	1	11	34	228	108	135	471	34
30/34	20	4	7	31	29	43	19	25	87	29	45	18	28	91	29	29	10	14	53	29	25	6	6	37	29	2			2	29	166	57	80	303	29
25/29	8	1	3	12	25	23	7	11	41	24	28	9	9	46	24	15	5	6	26	24	5	1	3	9	25						79	23	32	134	24
20/24	3	0	0	3	21	13	2	3	18	20	9	4	4	17	20	7	2	2	11	19	1	0	1	2	20						33	8	10	51	20
15/19	1	0	1	2	14	3	1	1	5	15	5	1	3	9	15	3	1	2	6	15	1	0		1	16						13	3	7	23	15
10/14	0	0	0	0	10	2	1	0	3	11	3	1	0	4	11	2	0	0	2	11	0	0		0	11						7	2	0	9	11
5/9	0	0		0	6	0	0	0	0	5	0	0	0	0	6	1	0		1	6											1	0	0	1	6
0/4	0			0	3	1	0		1	1	0	0		0	0																1	0		1	1
-5/-1											0	0		0	-3																0	0		0	-3

Miscellaneous

Cooling and Dehumidification Design Conditions for Georgia

Location	Cooling DB/MWB						Evaporation WB/MDB						Dehumidification DP/MDB/HR									Range of DB
	0.4%		1%		2%		0.4%		1%		2%		0.4%			1%			2%			
	DB	MWB	DB	MWB	DB	MWB	WB	MDB	WB	MDB	WB	MDB	DP	HR	MDB	DP	HR	MDB	DP	HR	MDB	
Albany	96	76	95	76	93	75	79	90	78	89	78	88	77	141	83	76	136	82	75	133	81	19.8
Athens	94	75	92	75	90	74	78	89	77	87	76	86	75	133	82	74	129	81	73	125	80	18.4
Atlanta	93	75	91	74	88	73	77	88	76	87	75	85	74	133	82	73	128	81	72	124	80	17.3
Augusta	96	76	94	76	92	75	79	91	78	89	77	88	76	135	84	75	130	83	74	127	82	20.2
Brunswick	93	78	91	79	88	78	81	89	80	88	79	87	78	147	86	78	144	85	77	141	84	14.4
Columbus, Metro Airport	95	76	93	75	91	75	79	89	78	88	77	87	76	139	82	75	134	82	74	130	81	18.0
Macon	96	76	94	75	92	75	79	91	78	89	77	88	76	136	83	75	132	82	74	129	82	19.3
Marietta, Dobbins AFB	94	74	91	74	89	74	77	88	76	87	75	86	74	134	82	73	130	81	72	123	79	17.1
Rome	96	74	94	74	91	74	78	90	77	89	76	88	75	134	83	74	130	83	73	127	83	20.7
Savannah	95	77	93	76	91	76	79	90	78	89	78	87	77	139	84	76	135	83	75	132	82	17.5
Valdosta, Regional Airport	95	77	94	76	92	76	80	90	79	89	78	88	77	144	83	76	139	82	76	136	82	19.4
Waycross	96	76	94	76	93	75	78	91	78	90	77	89	75	134	84	75	130	83	74	127	83	20.3

Typical Weather Data for Metro Atlanta Area

	Average Temp.	Heating Degree Days	Heating % Use	Cooling Degree Days (65°F)	Cooling % Use
January	42	716	24	0	0
February	45	563	19	0	0
March	52	400	13	12	1
April	62	133	3	37	2
May	69	37	1	170	10
June	76	5	0	329	20
July	79	0	0	422	25
August	78	0	0	409	25
September	73	7	0	247	15
October	62	130	4	44	2
November	52	394	13	0	0
December	44	636	22	0	0
YEAR	**61**	**3021**	**100**	**1670**	**100**

Climatic Conditions for Georgia Cities

City	WINTER Heating Degree Days	SUMMER Cooling Degree Days (65°F)
ALMA	1835	2289
BRUNSWICK	1611	2487
MACON	2279	2217
ROME	3122	1601

For more detail on climatic data for selected Georgia cities, refer to Climatic Data Base published by the Cooperative Committee of GAAIA/Georgia Power Company.

Miscellaneous

Wind Effect on Temperature*

Wind Speed (mph)	ACTUAL THERMOMETER READING (°F.) 30	20	10	0	-10	-20	-30	-40
	EQUIVALENT TEMPERATURE WITH WIND							
calm	30	20	10	0	-10	-20	-30	-40
5	27	16	6	-5	-15	-26	-36	-47
10	16	4	-9	-21	-33	-46	-58	-70
15	9	-5	-18	-36	-45	-58	-72	-85
20	4	-10	-25	-39	-53	-67	-82	-96
25	0	-15	-29	-44	-59	-74	-88	-104
30	-2	-18	-33	-48	-63	-79	-94	-109
35	-4	-20	-35	-49	-67	-82	-98	-113
40	-6	-21	-37	-53	-69	-85	-100	-116

*Per Army Medical Research

Formulae

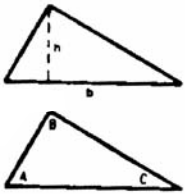
Discount Factors for Discrete Compounding

Factor Name	Converts	Symbol	Formula
Single Payment Compound Amount	*P* to *F*	*(F/P, i%, n)*	$(1 + I)^n$
Present Worth	*F* to *P*	*(P/F, i%, n)*	$(1 + I)^{-n}$
Uniform Series Sinking Fund	*F* to *A*	*(A/F, i%, n)*	$\frac{i}{(1 + I)^{n-1}}$
Capital Recovery	*P* to *A*	*(A/P, i%, n)*	$\frac{i(1 + I)^n}{(1+I)^{n-1}}$
Compound Amount	*A* to *F*	*(F/A, i%, n)*	$\frac{(1+I)^{n-1}}{i}$
Equal Series Present 'Worth	*A* to *P*	*(P/IA, i%, n)*	$\frac{(1+I)^{n-1}}{i(1+I)^n}$
Uniform Gradient	*G* to *P*	(P/G, i%, *n*)	$\frac{(1+I)^{n-1}}{i^2(1+I)^n} - \frac{n}{i(1+I)^n}$

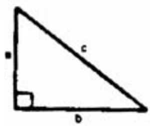
Geometric Formulae

PLANE

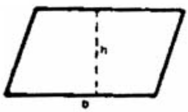
Triangle
Area $A = 1/2bh$
Sum of Angle Measures
$A + B + C = 180°$



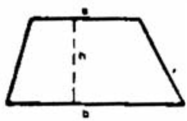
Right Triangle
Pythogorean Theorem
$a^2 + b^2 = c^2$



Parallelogram
Area $A = bh$



Trapezoid
Area $A = 1/2h(a + b)$

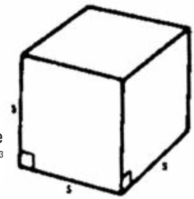


Circle
Area $A = \pi r^2$

Circumference
$C = \pi D$ or $2\pi r$
(22/7 and 3.14 are different approximations for π)

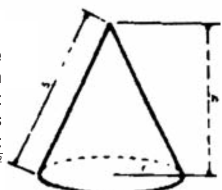
SOLID

Cube
Volume: $V = s^3$

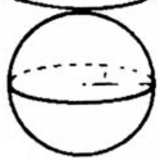


Right Circular Cylinder
Volume: $V = \pi r^2 h$
Lateral Surface Area:
$L = 2\pi rh$
Total Surface Area:
$S = 2\pi rh + 2\pi r^2$

Right Circular Cone
Volume: $V = 1/3\pi r^2 h$
Lateral Surface Area:
$L = \pi rs$
Slant Height:
$\sqrt{\;} S = r^2 + h^2$



Sphere
Volume $V = 4/3\pi r^2$
Surface Area $S = 4\pi r^2$



Formulae

Formulae for Solving Right Triangles

$\text{Sin } A = \frac{a}{c} = \text{Cos } B$ $\qquad$ $\text{Cot } A = \frac{b}{a} = \text{Tan } B$

$\text{Cos } A = \frac{b}{c} = \text{Sin } B$ $\qquad$ $\text{Sec } A = \frac{c}{a} = \text{Cosec } B$

$\text{Tan } A = \frac{a}{b} = \text{Cot } B$ $\qquad$ $\text{Cosec } A = \frac{c}{a} = \text{Sec } A$

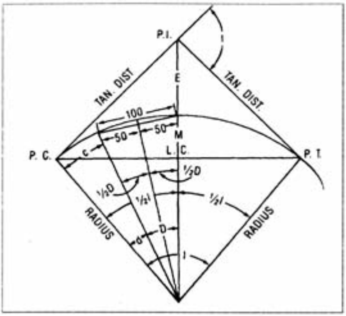
Given	Required	Solution
A, c	B, a, b	$B = 90° - A$, $a = C \sin A$, $b = C \cos A$.
A, b	B, a, c	$B = 90° - A$, $a = b \tan A$, $C = \frac{b}{\cos A.}$
A, a	B, b, c	$B = 90° - A$, $b = a \cot A$, $C = \frac{a}{\sin A.}$
a, c	A, B, b	$\sin A = \frac{a}{c}$, $\cos B = \frac{a}{c}$, $b = \sqrt{(c+a)(c-a)}$
a, b	A, B, c	$\tan A = \frac{a}{b}$, $\cot B = \frac{a}{b}$, $c = \sqrt{a^2 + b^2}$

FORMULAE FOR SOLVING OBLIQUE TRIANGLES

Given	Required	Solution
A, a, b	B, c	$\sin B = \frac{b \sin A}{a}$, $c = \frac{a \sin C}{\sin A}$
A, B, a	b	$b = \frac{a \sin B}{\text{Sin } A}$
a, b, C	A, c	$A + B = 180° - C$, $C = \frac{a \sin C}{\sin A}$
a, b, c	Area	side $\frac{a + b + c}{2}$, area $= \sqrt{s(s-a)(s-b)(s-c)}$
A, b, c	Area	area $= \frac{bc \sin A}{2}$
A, B, C, a	Area	area $= \frac{a^2 \sin B \sin C}{2 \sin A}$

Curve Formulae

D = Degree at Curve
1° = 1-Degree of Curve
2° = 2-Degree of Curve
P.C. = Point of Curve
P.T = Point of Tangent
P. I. = Point of Intersection
I = Intersection of Angle, Angle Between Two Tangents
L = Length of Curve, from P.C. to P.T.
T = Tangent Distance
E = External Distance
R = Radius
L.C. = Length of Chord
M = Length of Middle Ordinate
C = Length of Sub-Chord
D = Angle of Sub-Chord



$$R = \frac{L.C.}{2 \sin ½I}, \quad T = R \tan ½ I = \frac{L.C.}{2 \cos ½ I}$$

$$\frac{L.C.}{2} = R \sin \frac{I}{2}, \quad D\ 1° = R = 5730, \quad D\ 2° = \frac{5730}{2}, \quad D = \frac{5730}{R}$$

$$M = R\,(1 - \cos ½I), \quad R - R \operatorname{Cos} \frac{I}{2}$$

$$\frac{E + R}{R} = \sec \frac{1}{2}, \quad \frac{R - M}{2} = \cos 1$$

$$c = 2\,R \sin {}^{1}/_{2}d, \quad d = \frac{c}{2\,R}$$

$$L.C. = 2\,R \sin ½I, \quad E = R\,(\sec ½I - 1), \quad = R \sec \frac{I}{2} - R$$

Minutes in Decimals of a Degree

1'	.0167	**11'**	.1833	**21'**	.3500	**31'**	.5167	**41'**	.6833	**51'**	.8500
2	.0333	**12**	.2000	**22**	.3667	**32**	.5333	**42**	.7000	**52**	.8667
3	.0500	**13**	.2167	**23**	.3833	**33**	.5500	**43**	.7167	**53**	.8833
4	.0667	**14**	.2333	**24**	.4000	**34**	.5667	**44**	.7333	**54**	.9000
5	.0833	**15**	.2500	**25**	.4167	**35**	.5833	**45**	.7500	**55**	.9167
6	.1000	**16**	.2567	**25**	.4333	**36**	.6000	**46**	.7667	**56**	.9333
7	.1167	**17**	.2833	**27**	.4500	**37**	.6167	**47**	.7833	**57**	.9500
8	.1333	**18**	.3000	**28**	.4667	**38**	.6333	**48**	.8000	**58**	.9667
9	.1500	**19**	.3167	**29**	.4833	**39**	.6500	**49**	.8167	**59**	.9833
10	.1667	**20**	.3333	**30**	.5000	**40**	.6667	**50**	.8333	**60**	1.0000

Inches in Decimals of a Foot

1/16	3/ 32	1/8	3/16	1/4	5/16	3/8	1/2	5/8	3/4	7/8
.0052	.0078	.0104	.0156	.0208	.0260	.0313	.0417	.0521	.0625	.0729
1	2	3	4	5	6	7	8	9	10	11
.0833	.1667	.2500	.3333	.4167	.5000	.5833	.6667	.7500	.8333	.9167

Unit Conversions

Metric and English Measures

Linear Measure

1 centimeter	0.3937 inch
1 inch	2.54 centimeters
1 foot	3.048 decimeters
1 yard	0.9144 meter
1 meter	39.37 in. 1.0936 yds.
1 kilometer	0.62137 mile
1 mile	1.6093 kilometers

Square Measure

1 sq. centimeter	0.1550 sq. inch
1 sq. inch	6.452 centimeters
1 sq. ft.	9.2903 sq. decimeters
1 sq. meter	1.196 sq. yds.
1 sq. yd.	0.8361 sq. meter
1 acre	4840 sq. yds.
1 sq. kilometer	0.386 mile
1 sq. mile	2.59 sq. kilometers

Measure of Volume

1 cu. centimeter	0.061 cu. in.
1 cu. in.	16.39 cu. centimeters
1 cu. ft.	28.317 cu. decimeters
1 cu. meter	1.308 cu. yards
1 cu. yard	0.7646 cu. meter
1 liter	1.0567 qts. liquid
1 qt. liquid	0.9463 liter
1 gallon	3.785 liters

Weights

1 gram	0.03527 ounce
1 ounce	28.35 grams
1 kilogram	2.2046 pounds
1 pound	0.4536 kilogram
1 metric ton	1.1023 English tons
1 English ton	0.9072 metric ton

Approximate Metric Equivalents

1 liter	1.06 qts. liquid, 0.9 qt. dry
1 meter	1.1 yards
1 kilometer	5/8 of a mile
1 kilogram	2-1.5 lbs.
1 metric ton	2.2 pounds

Miscellaneous Data

1 Ton Refrigeration	= 12,000 Btu/hr.; 200 Btu/min.
1 Btu	= 6.65 grains (latent heat water vapor); 0.293 watt hours
1 Grain (water)	= 0.15 Btu (latent heat)
1 Pound	= 7,000 grains
1 Pound (air)	= .24 Btu; sensible heat per (°F.); 2.0416" Hg (64°F.)
1 lb./sq. in.	= 2.309" Hg (64°F.)
1 atmosphere	= 14.7 lbs./sq. in.
1 watt hour	= 3.415 Btu
1 kilowatt	= 1.34 horsepower; 56.92 Btu/min.
1 Horsepower	= 0.746 kilowatts; 42.44 Btu/min.
1 Boiler H. P.	= 33,523 Btu/hr.; 10 kW; 34.5 lbs./hr.
1 Gallon (US)	= 231 cu. in.; 8.34 lbs. (water 60°F.)
1 Cu. Ft. (water)	= 62.37 lbs.

Pressure

1 oz. per sq. in. = 1.73 in. water

1 in. mercury = 7.85 oz. per sq. in.

1 in. mercury = 13.6 in. water

1 in. water column = 0.578 oz. per sq. in.

1 oz. per sq. in. - 0.127 in. mercury

1 in. water = 0.0735 in. mercury

1 lb. per sq. in. = 16 oz. per sq. in. = 2.036 in. mercury = 27.7 in. water

1 atmosphere = 14.7 lbs. per sq. in. = 760 mm mercury = 2992 in. mercury

Definitions

A.F.U.E.—Annual Fuel Utilization Efficiency. The annual seasonal efficiency which accounts for part load operation, cyclic operation, standby and flue losses in a fossil fuel heating system.

AMPACITY—The current carrying capacity of a conductor.

BTU—(British Thermal Unit). The amount of heat energy required to raise the temperature of one pound of water, one degree fahrenheit.

BTUH HEAT LOSS—the amount of heat that escapes, from warmer to colder areas, through walls, ceilings, floors, windows, doors and by infiltration in one hour's time.

CIRCUIT—A conductor or a system of conductors through which an electric current flows.

CIRCUIT BREAKER or FUSE—A load limiting device that automatically interrupts an electric circuit if an overload condition occurs.

COOLING TON—A measure of cooling capacity equal to 12,000 BTU per hour.

C.O.P.—(Coefficient of Performance). The ratio of the rate of heat delivered versus the rate of energy input, in consistent units, of a complete, operating heat pump system under designated operating conditions.

CYCLE—Frequency of alternating current expressed in hertz. 60 cycles per second = 60 hertz.

DEGREE DAY—A unit that represents one degree of declination from a given point (as 65°F) in the mean outdoor temperature of one day and is often used in estimating fuel requirements of buildings.

E.E.R.—Energy Efficiency Ratio. Used in the efficiency rating of room and central air conditioners. E.E.R. = BTU ÷ watts.

E.F.L.H.—Equivalent Full Load Hours. Annual hours used to estimate energy consumption of end use equipment.

HEAT PUMP—A space conditioning unit that provides both heating and cooling. By means of a compressor and reversing valve system, a heat transfer liquid is pumped between the indoor and outdoor units, moving that heat into a building during cold weather and out of it during warm weather.

HERTZ—The number of cycles of alternating current per second, such as 60Hz.

KILOWATT—A unit of electrical power equal to 1,000 watts.

KILOWATT HOUR—Represents the use of 1,000 watts of electricity for one full hour.

LOAD FACTOR—The ratio of the average load in kilowatts supplied, during a designated period, to the peak load occurring during that period.

$$\text{Load Factor} = \frac{\text{kWh supplied in period}}{\text{Peak kW in period x hours in period}}$$

Load factor is a measure of efficiency. 100% efficiency would require the continuous use of a given amount of load for every hour of the month.

OHM's LAW—In a given circuit, the amount of current in amperes is equal to the pressure in volts divided by the resistance in ohms.

$$\text{Current} = \frac{\text{(Pressure) Volts}}{\text{(Resistance) Ohms}} \text{ or } I = \frac{E}{R}$$

POWER FACTOR—It is the ratio of actual power being used in a circuit, expressed in watts or kilowatts (kw), to the power which is apparently being drawn from the line, expressed in voltamperes or kilovoltamperes.

What does this mean in the practice of effective energy management and energy cost control? With both values being equal (kW = kVA) a ration of 1 could exist or a power factor of 100%. But if a load demands 2kVA while the actual productive power potential is 1kW, the power factor would be 50%. This means that in using only half of the power supplied to you, the utility still must supply the other half which you are using but not directly paying for—to supply what is known as wattless power or reactive power which is expressed in vars or kilovars (kvar). Low power factor penalties may be a part of rate schedules.

RELATIVE HUMIDITY—The ratio between the actual water vapor content and the total amount of water vapor content possible under the same conditions of temperature and pressure.

S.E.E.R.—Seasonal Energy Efficient Ratio. The total cooling of a central air conditioner BTU's during its normal usage period for cooling (not to exceed 12 months) divided by the total electric energy input in watt-hours during the same period.

S.P.F.—Seasonal Performance Factor. The ratio of seasonal kWhs used by heat pumps versus the seasonal kWhs used by resistance electric heat for the same space under the same conditions.

SINGLE PHASE—A circuit energized by a single alternating voltage.

THERM—A measurement of gas containing 100,000 BTU. As there are approximately 1,000 BTU per cubic foot, there are approximately 100 cubic feet of gas per therm.

THERMAL CONDUCTIVITY VALUES

- **U Factor**—The rate of heat flow through one square foot of completed structural sections, such as wall, glass, ceiling, etc. in one hour with a temperature difference of one degree between the inside and outside surfaces.

Note: To convert to watts/sq. ft. (W)

W = U Factor x Temperature Difference ÷ 3.413

K Factor—The rate of heat flow in Btuh through one square feet of building material, one-inch thick, in one hour with a temperature difference of one degree between the two surfaces.

C Factor—The definition is the same as for K Factor except that C Factors are used for materials other than those that are one-inch thick, such as one-half inch gypsum board or eight-inch concrete block.

R Factor—The rate at which insulation, building material or a building structure resists the passage of heat in any direction.

Note: The U, K, and C Factors should be kept as low as possible and the R factor as high as possible.

THREE PHASE—Three separate sources of alternating current arranged so that the peaks of voltage follow each other in a regular repeating pattern.

VOLT—The push that moves electrical current through a conductor.

WATT—The rate of flow of electrical energy. One watt equals the flow of one ampere at a pressure of one volts. (Watts = Volts x Amperes).

* Graph instructions for Page 6:

Using the Z-Chart

1) Locate the cost of natural gas on the x-axis.

2) Choose the line that represents the efficiency of the gas equipment.

3) Find the intersection of these two points. The corresponding y-axis value represents the equivalent incremental (not average) cost per kWh for an electric device with a COP of 1.

To determine the equivalent cost for heat pumps, first determine the cost for a COP of 1 and then multiply this value by 2.

Comparisons between electric and gas air conditioning can be done similarly.

Useful Web Addresses

Georgia Power Company, A&E Site
http://www.georgiapower.com/AandE

Georgia Power
http://www.georgiapower.com

Southern Company
http://www.southerncompany.com

Georgia Public Service Commission
http://www.psc.state.ga.us/

U.S. Green Building Council (LEED)
http://www.usgbc.org/

U.S. Dept. of Energy (EREN)
http://www.eren.doe.gov/

ASHRAE
http://www.ashrae.org

Illuminating Engineers' Society
http://www.iesna.org

AIA, Georgia Chapter
http://www.aiaga.org

Air Conditioning and Refrigeration Institute
http://www.ari.org

American Council of Engineering Companies, Georgia
http://www.acecga.org

The Georgia Engineer
http://www.thegeorgiaengineer.org